

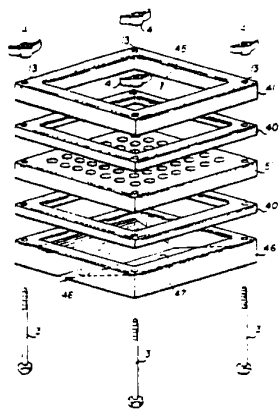


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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification <sup>5</sup> :          B01D 25/12, 63/00, B01J 19/00          B01L 9/00, 11/00          C08F 283/00, 285/00          C07H 21/00, C07K 1/06, 5/00          C07K 7/00, 15/00, 17/00          C08L 89/00, C12Q 1/00          C12P 19/04, 19/38, 21/06          G01N 21/00, 33/00, 33/543          G01N 33/544, 33/545, 33/546          G01N 33/552</p>	<p>A1</p>	<p>(11) International Publication Number: <b>WO 94/05394</b></p> <p>(43) International Publication Date: 17 March 1994 (17.03.94)</p>
<p>(21) International Application Number: PCT/US93/08267</p> <p>(22) International Filing Date: 2 September 1993 (02.09.93)</p> <p>(30) Priority data:          07/939,065 2 September 1992 (02.09.92) US          08/079,741 18 June 1993 (18.06.93) US</p> <p>(71) Applicant: ARRIS PHARMACEUTICAL CORPORATION [US/US]; 385 Oyster Point Boulevard, South San Francisco, CA 94080 (US).</p>	<p>(72) Inventors: HUDSON, Derek ; 52 EL Cerrito Avenue, San Anselmo, CA 94960 (US). JOHNSON, Charles, R. ; 2670 Hilgard Street, Berkeley, CA 94709 (US). GIEBEL, Lutz ; 1421 Oak Grove, Apt. 206, Burlingame, CA 94401 (US).</p> <p>(74) Agent: DULIN, Jacques, M.; Rosenblum, Parish &amp; Isaacs, 160 W. Santa Clara St., Fifteenth Floor, San Jose, CA 95113 (US).</p> <p>(81) Designated States: AU, CA, JP, NO, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p><b>Published</b>  <i>With international search report.</i></p>	

(54) Title: SPECIFICATION METHOD AND APPARATUS FOR PEPTIDE SYNTHESIS AND SCREENING



## (57) Abstract

Method and apparatus for synthesizing a combinatorial library of families of biopolymers, such as polypeptides, oligonucleotides and oligosaccharides, on a reusable, spatially addressable solid phase plate (5'), typically in arrays of 4x4 to 400x400. In the case of peptides, such as synthesis of hexapeptides, the library contains one to three, typically two, positions in the sequence which are uniquely identified by the spatial address location. The preferred plate (5') embodiment employs a hydrophilic polar multi-functionalized polymer film coating discs or "winks" (50) of porous polyolefin which are removably received in holes (51) in the plate (5'). The plate (5') is employed with a vacuum block system (46, 47, 48) to assist in washing, deprotection of protected monomers, such as Fmoc protected amino acids, and screening of immobilized, synthesized hexapeptides, for example, to determine which synthetic hexapeptides specifically bind to functional target proteins, such as enzymes, receptors and antibodies. Following identification of the known synthetic polypeptides giving the greatest affinity for the arrayed positions in the sequence, optimal binding for the complete peptide sequence is determined by an iterative process replacing formerly mixed positions with known amino acids at defined spatial addresses.

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SPECIFICATION  
METHOD AND APPARATUS FOR PEPTIDE  
SYNTHESIS AND SCREENING

BACKGROUND OF THE INVENTION:

This invention relates to methods and apparatus for preparing a non-volatile, reusable, Addressable Synthetic Biopolymer Combinatorial Library (ASBCL) having known sequences at identifiable designated addresses arrayed on a permanent substrate, which library is rapidly creatable by a unique and simple slotted block system. The invention also relates to the use of ASBCLs to screen for sequences having biologic, biochemical, biomedical or therapeutic activity relative to a specified target. The invention permits rapid optimization of leads for identification of active components when applied to the specific area of peptides. The invention may be termed PILOT, for Peptide Identification and Lead Optimization Technique.

Moderate length peptides have attracted considerable research and commercial interest by virtue of the properties some exhibit in enhancing, blocking or otherwise affecting the activity of receptors, microbes, and other molecules deemed biologically significant. Specifically, hexapeptides have proven to have a sufficient chain length to block much larger molecules such as receptors, enzymes and antibodies. Thus, synthetic and natural hexapeptides have exhibited diverse therapeutic properties, among them: Antimicrobials with minimum inhibitory concentrations an order of magnitude less than known natural antimicrobial peptides; bactericides; antivirals; activity as antigenic determinants; and the like. The problem is that there are 64 million (64m) hexapeptide combinations for the twenty L-amino acids, and another 64m for the D-amino acids. Indeed if the selection were made from all of the L and D combinations the number amounts to 4.096 billion. Since there are in turn millions of biologically/medically

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1 significant targets, preparing a complete suite of just  
2 64m L-hexapeptides and assaying activity for each of the  
3 millions of targets is, practically speaking, an infinite,  
4 and therefore, impossible, task.

5 Accordingly, the Synthetic Peptide Combinational  
6 Library (SPCL) approach has recently resulted in a  
7 manageable approach to the problem of screening for a  
8 unique hexapeptide among the 64m that is the most active  
9 for a given target. In order to be feasible, libraries of  
10 large numbers of hexapeptides, on the order of 100,000 or  
11 so at a time, must be prepared in quantities sufficient to  
12 result in a positively determinable reaction.

13 There are currently five basic library techniques  
14 offered: viral approaches (originated by George Smith of  
15 LSU, and by Cetus and Affymax independently); the Chiron  
16 Geysen polyethylene pin system; the Houghten approach  
17 using Tea-bags; the Selectide bead approach; and the  
18 Affymax Chip approach. The latter four have distinct  
19 advantages over the viral approach in which peptide  
20 libraries are displayed by bacteriophages (viruses that  
21 prey on bacteria). A short degenerate oligonucleotide  
22 encoding all combinations of a short peptide sequence is  
23 cloned into Gene III or VIII of a filamentous phage and  
24 expressed on the phage surface. Recombinant phage are  
25 screened with the target molecule (e.g. receptor), and  
26 phage expressing a certain peptide that binds to the  
27 target are identified. Nucleotide sequence analysis of  
28 the recombinant Gene III or Gene XIII identifies the  
29 peptide sequence displayed by the binding phage.

30 The problem with the viral approach is that the range  
31 of peptides is limited to those tolerable by virus and E.  
32 Coli. That is, only a limited suite of peptides can be  
33 produced from among the 64m possible hexapeptides, and  
34 likewise for the even greater numbers of longer peptides.  
35 Additionally, only L- amino acids are allowed, and each  
36 individual hexapeptide of the library is produced within  
37 the phage as fusion products. This reduces the  
38 flexibility of the sequences, and may mask them entirely.

39 Methods for synthesis and display of peptides on

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1 surfaces as well as techniques for binding from partial  
2 sequences were reviewed by H. Mario Geysen in Geysen, H.M.  
3 et al, Synthetic Peptides as Antigens, Wiley Chichester  
4 (Ciba Foundation 119), 130-149 (1986), shown in U.S.  
5 Patent 4,833,092 (19\_\_\_\_). Geysen used functionalized  
6 polyethylene pins clustered to fit 96 hole microtiter  
7 plates. This Chiron system also relies on the method  
8 shown in Rutter-Santi patent 5,010,175 of preparing  
9 peptide sequences by providing constituent amino acids in  
10 concentrations relative to each other based on their  
11 relative coupling constants so that the resulting peptide  
12 mixture contains peptides in equimolar amounts. Chiron  
13 reports that its recent patent 5,194,392 entails  
14 synthesizing up to 1000 peptides a day on special pins,  
15 evidently a reference to the Geysen pin system of  
16 4,833,092. The peptides can be used to "map" regions  
17 called epitopes in any protein of interest, such as  
18 antigen regions that trigger an immune response by T-  
19 cells.

20 The Selectide bead approach uses vast quantities of  
21 spherical crosslinked polymer beads (Millipore or  
22 Cambridge Research Laboratories polyacrylamide beads or  
23 Rapp Tentagel polystyrene) divided into 20 equal piles,  
24 each of which then has a different L-amino acid coupled to  
25 all the beads in the pile. The bead piles are then  
26 combined and thoroughly mixed. The resulting single pile  
27 is again divided into 20 different piles, each of which is  
28 reacted with a different one of the 20 different L-amino  
29 acids. This Divide, Couple and Recombine process (DCR) is  
30 repeated through six reactions to produce hexapeptides  
31 bound to the beads. The beads are then screened against  
32 a "target" molecule which is marked with a conjugated  
33 enzyme, such as horseradish peroxidase. The target  
34 "sticks" to active hexapeptide(s). The bead is rendered  
35 visible by adding a substrate for the enzyme which  
36 converts it to a colored dye which is precipitated within  
37 the beads, and then the visually identified bead(s) are  
38 picked out with tweezers. The peptides on the beads are  
39 then analyzed, for example by the Edman sequencing method,

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1 and soluble versions produced in a synthesizer. The  
2 initial screening (locating the target bead(s)) takes only  
3 days, the makeup of each identified hexapeptide is  
4 unknown, and the analysis and synthesis for confirmation  
5 and further work takes much longer.

6 The Houghten (Iterex) Tea-Bag method, shown in U.S.  
7 Patent 4,631,211, employs methylbenzhydrylamine (MBHA)  
8 polystyrene beads in a number of foraminous containers,  
9 e.g. porous polypropylene bags (Tea-Bags), to prepare a  
10 truncated SPOT. In order to shorten the processing time,  
11 the Tea-Bag process employs partially known, partially  
12 undetermined hexapeptide sequences in repeated screenings,  
13 followed by iterative resynthesis to replace the unknown  
14 AA sequence positions with known AAs, i.e., A-O<sub>1</sub>O<sub>2</sub>O<sub>3</sub>XXX, A-  
15 O<sub>1</sub>O<sub>2</sub>O<sub>3</sub>O<sub>4</sub>XX, etc. The method works on the assumption that a  
16 biologically significant response can be detected from a  
17 solution which contains hundreds of thousands of inactive  
18 components.

19 The Tea-Bag process typically uses 18 of the 20 L-Aas  
20 (cysteine and tryptophane are omitted in the initial  
21 library for ease of synthesis), starting with 104,976  
22 combinations of non-determined tetrapeptide resins (XXXX-  
23 peptide resins) in 324 aliquots, and adds the 324 known  
24 dipeptide sequences (18<sup>2</sup>) in the terminal two positions.  
25 For epitope determination of antibody binding, the 324  
26 pools are screened to see which best inhibits binding of  
27 the target antibody with its natural antigen. The most  
28 active amino terminal dipeptide sequences are then  
29 incorporated into a further set of 20 pools in which the  
30 third residue is varied. These are rescreened for low IC.  
31 The most active sequences are again reincorporated  
32 iteratively to define positions 4-6 to finally obtain a  
33 characterized active hexapeptide.

34 The foraminous container of the Tea-Bag must retain  
35 the solid phase beads, yet have a sufficient number of  
36 openings to permit ready entrance and exit of solvent and  
37 solute molecules at the reaction temperature, but bar exit  
38 of the solid phase. While the synthesis is the standard  
39 Merrifield technique, new linking groups that attach the

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1  $X_n$ -peptide to the styrene bead supports are disclosed.  
2 This process can be characterized as not calling for a  
3 continuous support, and it is not addressable.

4 The Affymax "chip" approach described in PCT  
5 publication W090/10570, and in Fodor, P.A. et al, Science,  
6 251 (1991) 767, is a method for multiple peptide synthesis  
7 on a solid support which uses synthesis and fluorescent  
8 detection on the silica surfaces of flow through cells,  
9 photolabile protecting groups and photolithographic  
10 masking strategies to make arrays. Photolabilely blocked  
11 amino groups are chemically attached (bonded) to a silicon  
12 chip, then irradiated through a patterned mask to  
13 selectively remove the blocking groups in a pre-arranged  
14 pattern. An amino acid will bond by addition only to the  
15 irradiation exposed areas. Additional masks are imposed  
16 and radiation applied as a prelude to adding second amino  
17 acids. Each amino acid added can include a blocking group  
18 so that further addition to that site occurs only after  
19 irradiation unblocking. Repeating the process with plural  
20 masks builds location specific polypeptides. When the  
21 chip is exposed to the target molecule, it may stick to  
22 one or more locations. By checking coordinates on a map  
23 of the chip, the peptide is identified. However, this  
24 process does not work with target molecules stuck to, or  
25 part of, cells, and there are exposure problems during  
26 processing, i.e., some AA's are light sensitive and cannot  
27 be used. Further, the reactions at the surface are not  
28 complete; for example, where reaction completion is only  
29 90%, by the 6th iteration to obtain a hexapeptide, only  
30 half of them will be made properly.

31 There is clearly a need in the art for a peptide  
32 synthesis and screening process that is rapid and  
33 accurately identifies the active peptides from amongst  
34 those in an extended, reusable SPCL. Accordingly, it is  
35 among the objects of this invention to provide methods and  
36 apparatus for creating a non-volatile, reusable  
37 Addressable Synthetic Biopolymer Combinatorial Library  
38 (ASBCL) having known amino acid sequences at identifiable  
39 designated addresses arrayed on a permanent substrate for

1 rapid screening of target receptors and molecules by use  
2 with the Peptide Identification and Lead Optimization  
3 Technique (PILOT) which employs a simple slotted block  
4 system for rapid multiple amino acid addition reactions to  
5 build peptides of known sequences at identifiable  
6 designated addresses in an X-Y coordinate array on a  
7 variety of planar substrates, and preferably uses sintered  
8 polyolefin discs having thereon ultra-thin HPMP films,  
9 called thin-film HPMP Winks, in plate, slotted block and  
10 vacuum block assemblies, to permit display of assembled  
11 synthon molecules in an unhindered, near-aqueous  
12 environment, and thereby permit high quality peptide  
13 ligand synthesis, high ligand loading, efficient binding  
14 of radioactive target molecules and facile removal of  
15 unbound targets by suction washing, and repeated  
16 regeneration thereof.

17

18 **SUMMARY OF THE INVENTION:**

19 The invention comprises methods and apparatus for  
20 preparing non-volatile, reusable, Addressable SBCLs  
21 (ASBCLs) or SPCLs (ASPCLs), having known arrayed dipeptide  
22 amino acid sequences incorporated at any desired and known  
23 position within any biopolymer (e.g., polypeptide)  
24 sequence of length producible by chemical synthesis  
25 methodology, in which up to 6 positions (typically 4) may  
26 be composed of mixtures of residues, the remaining  
27 positions comprising specified amino acids. The arrayed  
28 peptides are identifiable from designated addresses  
29 provided on a permanent, reusable substrate-containing  
30 plate which permits creation of an ASPCL, typically within  
31 a day. While the discussion herein is with reference to  
32 hexapeptides by way of example, the principles of the  
33 invention are applicable to any binding determinant  
34 biopolymer to produce an ASBCL for interaction with any  
35 biologically significant target. These library peptides  
36 are also termed ligands.

37 The ASBCLs of this invention can uniquely identify  
38 the binding determinant biopolymer, e.g. an active  
39 hexapeptide, at a unique X-Y coordinate axis upon bonding



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1 with or adhering to a fluorescently labeled, radio-labeled  
2 or enzyme-linked target molecule or receptor, e.g., in  
3 solution flowed into contact with the ASPCL-bearing  
4 substrate. The amino acids and peptide sequences are  
5 substantially equimolar concentrations on the substrate,  
6 so good quantitative activity is determinable by the  
7 fluorescent or radio intensity, or by the optical density  
8 of the dye product formed in the enzyme linked probing.

9 In addition, the hexapeptide array is permanently  
10 bound to the substrate i.e., is non-volatile, and at each  
11 substrate site on the array plate on the order of  $1\mu$  mole  
12 or more can be bonded. The target molecule can be washed  
13 off the substrate plate so that it can be reused  
14 repeatedly, particularly for diagnostic testing, as well  
15 as rapid active peptide screening on a wide variety of  
16 target receptors. For example, a preselected library of  
17 peptides, or any other condensation chemistry-based  
18 screening agent, may be permanently bonded to a substrate  
19 as a diagnostic tool. One example involves exposing an  
20 ASPCL plate of this invention to one or more aliquots of  
21 a serum which requires diagnosis, and then visualizing  
22 binding by passing a fluorescently or radiolabeled anti-  
23 IGG antibody over the ASPCL plate. Consequently, one or  
24 more conditions, such as the presence of antibodies to  
25 HIV-1, or the presence of other viral infections can be  
26 rapidly and simply diagnosed.

27 More broadly considered, the peptide may be any  
28 biopolymer. Thus the term ASBCL applies to the library  
29 on the identifiable designated addresses arrayed on the  
30 permanent, reusable substrate plate. It should be  
31 understood that the term "substrate" as used herein  
32 includes broadly but is not limited to: a) polyolefin  
33 plate alone, or, preferably, an activated plate carrying  
34 a plurality of substrate discs; b) a plate with a bead or  
35 gel substrate, amino functionalized or bare, (receptor  
36 substrate); c) such beads or gels with spacer arms, amino-  
37 functionalized or bare, (spacer receptor substrates); and  
38 d) reacted substrates i.e. such substrates above with one  
39 or more Aas or peptides linked thereto.

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1       The apparatus system of this invention comprises  
2       employing an inert substrate support plate, such as a  
3       polyolefin polymer, having a plurality of discrete sites  
4       (such as holes for retainingly engaging removable  
5       substrate discs, called winks, or small, well-like,  
6       shallow flat-bottomed circular or square depressions) in  
7       a spaced array, e.g., 4x4, 10x10, 16x16, 20x20, 40x40,  
8       100X100, 400x400, or any other desired number. The wink-  
9       holding plate array is presently preferred. Each of the  
10      sites are permanent uniquely addressable locations for  
11      assembly of the biopolymer chains or attachment of  
12      preactivated molecules. Each site includes an amino  
13      functionalized substrate media such as a sintered  
14      polyolefin (polyethylene or polypropylene) disc, glue-  
15      bonded beads, or chemically grafted polymeric films, which  
16      may be gel-type films. Any conventional peptide  
17      substrate, media, or addition chemistry-based agent  
18      substrate, may be used.

19       The preferred substrate is a 1/4" diameter sintered  
20      polyethylene disc of approximately 1/8" thickness, which  
21      is coated with an ultra-thin Hydrophilic Polar Multi-  
22      functionalized Polymer (HPMP) film, herein called a  
23      "wink". The film and methods of anchoring to the  
24      polyolefin are disclosed in more detail in our co-pending  
25      priority application U.S. Serial No. 08/019,725, the  
26      disclosure of which is incorporated by reference herein to  
27      the extent needed.

28       The film is preferably carboxymethyl dextran carbodi-  
29      imide coupled to the polyolefin disc surfaces after  
30      functionalizing them with a diamino-substituted  
31      polyethylene glycol spacer arm.

32       Another example of a film is a hydrolyzed or partly  
33      hydrolyzed chitin (herein chitin/chitosan) having from  
34      about 1 to about 100 sugar moieties per amino group which  
35      may be coupled to the polyolefin disc surface with mono-  
36      amino substituted polyolefin glycol spacer arms after  
37      functionalizing most of the amino groups with protective  
38      functionalities such as t-Boc or Fmoc that can be removed  
39      later. The degree of alkaline hydrolysis of the chitin

1 controls the solubility of the resulting chitosan. The  
2 amino group and hydroxyl on the sugar moieties permits the  
3 chitin/chitosan to be bifunctional providing a wide  
4 variety of tether linkages to ligands through either or  
5 both types of groups. The amino groups provide a  
6 controllable positive charge that may be advantageous in  
7 certain affinity binding environments. The polymer film  
8 molecular weight may range from about 50,000 to about 1  
9 million.

10 The films permit display of assembled synthon molecules  
11 (ligands) in an unhindered, near aqueous environment.  
12 These substrates permit high quality peptide (ligand)  
13 synthesis, high ligand loading in the film in the range of  
14 50-100 nmole loading, efficient affinity binding of  
15 radioactive or fluorescent labeled target molecules, and  
16 easy removal of unbound targets by suction washing, and  
17 repeated regeneration and reuse of the library. The  
18 substrate discs are easily pressed into and removed from  
19 holes bored partway through a substrate carrier plate,  
20 which preferably includes at least one smaller through-  
21 hole to permit rapid and thorough suction removal and  
22 washing of the array of substrate discs in the carrier  
23 plates. A vacuum base plate is used with the array carrier  
24 plate to facilitate the excess target solution removal and  
25 washing steps in the common synthesis and probing steps.

26 Examples of bead type substrates are  
27 polydimethylacrylamide (PDMA) particles, silica beads,  
28 MBHA polystyrene beads, and the like, which are glued to  
29 the substrate areas of the support plate. The presently  
30 preferred bead substrate is Kieselguhr-encapsulated PDMA  
31 particles (Pepsyn-K from Millipore Corp.), secured to a  
32 polyethylene plate with a low temperature (<100 degrees C)  
33 hot-melt polyethylene adhesive. The preferred polymeric  
34 film is chemically grafted to the surface of the wells by  
35 a process disclosed herein, and is particularly useful for  
36 screening involving large proteins.

37 Two methods of attachment of amino-functionalized  
38 polymers to form substrate areas on the plates are  
39 disclosed by way of examples of the principles of the

1 invention; in situ polymerization (disclosed in detailed  
2 examples); and bonding of a pre-polymerized material to  
3 activated areas on the plate (disclosed in general). The  
4 first polymerizes acryloylated monomers and crosslinking  
5 agents onto acryloyl groups attached to the areas of the  
6 polyolefin surface (plate activation). This establishes  
7 a gel-type polymer covalently grafted into the  
8 depressions. This polymer, since it may possess low  
9 structural strength, i.e. it need not have high structural  
10 strength, can be prepared from monomers at low  
11 concentration and with a low molar percentage of cross-  
12 linking. The resulting gel substrate materials are  
13 therefore highly permeable to proteins, thus greatly  
14 improving the sensitivity of detection. The gel film may  
15 then be amino functionalized.

16 A spacer arm derivative is attached to the functional  
17 amino groups of the resultant films. These spacer arms,  
18 which are also used for the glued beads, increase  
19 sensitivity since they reduce unfavorable steric and  
20 electronic interactions between the incoming tagged  
21 protein and the polymer backbone. An ideal spacer is non-  
22 hydrophobic, incapable of forming aggregates by hydrogen  
23 bonding, and typically longer than 10Å. A variety of  
24 materials, including functionalized polyethylene glycols,  
25 sugars, and short natural and unnatural peptides may be  
26 used as spacers.

27 The second (pre-polymerized) method of attachment of  
28 functional polymers involves attachment of preformed  
29 amino-functionalized polymers to the designated areas on  
30 the inert (polyolefin) support plate itself, or on the  
31 sintered polyolefin winks (discs) which are retained in  
32 the plate. The preformed polymer itself serves as a  
33 spacer arm, and access of proteins is improved as compared  
34 to the in situ gel type polymers. Examples of preformed  
35 amino-functionalized polymers include polyethyleneimine,  
36 polyallylamine, long chain functionalized sugars (e.g.  
37 dextrans and chitosans), polyamino acids (e.g. poly-L-  
38 lysine) and the like. They can be coupled to acid  
39 chloride activated plate areas by reactions of the type

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1 described herein. We prefer to use a 500,000 MW dextran  
2 that is amino-functionalized pre- or post-attachment to  
3 the plate area, or to the winks.

4 For the array preparation steps, an elastomeric  
5 sealing gasket having a plurality of holes or slots  
6 therethrough aligned with the substrate areas is placed  
7 over the substrate array plate or wink carrier plate, and  
8 a slotted block is placed over the gasketed plate so that  
9 individual slots align with rows of substrate areas. When  
10 the wink carrier plate is used, a solid non apertured  
11 gasket is placed below the wink plate to seal the through-  
12 holes, and then placed on a base plate. The assembly of  
13 the plate, slotted block and appropriate gasket(s) is  
14 clamped together for use.

15 Since each area is part of a predetermined array,  
16 each defined substrate area has a unique X-Y coordinate  
17 address, such as: Row 1, position 1; Row 2, position 20;  
18 Row 3, position 78; to Row  $X_n$ , position  $Y_m$ . Any desired  
19 address system may be used, such as sequential numbers for  
20 each succeeding area, dual alpha system (AA, AB, AC etc.),  
21 or alpha numeric (A1, A2...B1, B2...).

22 The slotted block has a height sufficient to provide  
23 a well of sufficient volume to receive reaction solution  
24 having selected moieties for bonding with the exposed  
25 substrate address area, or for reaction with a previous  
26 moiety. Each well can receive a different reactant, e.g.  
27 a blocked AA, so that each row has a different  $A_n$  position  
28 AA. Next, the reactants are removed from the slots in the  
29 block, e.g. by decanting or suction, then the amino  
30 blocking group removed by a deblocking agent, e.g.  
31 piperidine. Then the slotted block (and slotted gasket if  
32 such is used) is rotated horizontally 90°, and each slot  
33 well receives another, same or different, reactant so that  
34 the  $A_{n+1}$  position has a predetermined AA. Where the  
35 sequence of Aas are the same in each well at each block  
36 orientation, turning the block 90° produces all 400  
37 combinations of dipeptides for a 20 slot block/400  
38 substrate area plate system. Iterative application of 3  
39 such plates, two positions being optimized at a time,

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1 allows for the identification of the single optimal  
2 binding peptide from a 64m hexapeptide SPCL. The  
3 substrate areas can be quite small to provide peptides in  
4 adequate (picomolar) amounts, e.g., the 1/4" diameter  
5 winks.

6 As an illustration of another method of use of the  
7 system of this invention, a random sequence of all XXXX-  
8 tetrapeptides on Pepsyn-K beads is prepared, and these  
9 beads adhered to the substrate areas. Alternately and  
10 preferably, a polymeric film gel (HPMF) may be prepared on  
11 a plurality of winks, which are then reacted in a flask  
12 (100 ml/100 winks) of an automated peptide synthesizer to  
13 produce the random XXXX-tetrapeptide mix. These winks are  
14 then pressed into the holes in a wink carrier plate. The  
15 wink plate is placed on a border or periphery gasket on a  
16 vacuum block, and then overlain with another border gasket  
17 and a "window frame" border block and clamped.

18 Then, using the system of this invention, the  
19 terminal two Aas can be added thereto in the all-  
20 combinations 20x20 array via the rotation of the slotted  
21 block assembly. Alternately, a known dipeptide can be  
22 added to the end terminal by two cycles of reaction with  
23 the vacuum block, say all VY, i.e., VY at all positions.  
24 A reaction cycle is defined as deblocking the prior  
25 reaction step AA, and reacting with the next blocked AA.  
26 The resulting hexapeptides are screened (probed) by  
27 exposure to labeled targets. This is done in the vacuum  
28 block assembly.

29 A deductive process involving iterative resynthesis  
30 of successively smaller libraries can be used to  
31 successively characterize the resulting screening-active  
32 hexapeptide. Alternately, the procedure and apparatus of  
33 this invention can work from a defined middle dipeptide  
34 with random ends, followed by replacement of each end in  
35 sequence with known dipeptides. Likewise 4 or 5 residues  
36 may be mixed, or an array of any kind of peptide,  
37 including those including one or more non-natural Aas, can  
38 be employed on the reusable substrate of this invention.

39 The use of winks receivingly engaged in the support

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1 address area is preferred for diagnostic or drug use  
2 applications, as single preselected, known-sequence  
3 peptide-containing winks can be prepared in place in the  
4 carrier plate, or separately prepared in an automated  
5 synthesizer and inserted in the holes in the support in  
6 specified address(es). Likewise, DNA moieties can be  
7 bonded to the support, in which case a 16x16 array, or an  
8 array of 16-4x4 subarrays, on a single plate is preferred.

9 Advantages of the apparatus and methods of this  
10 invention include: Synthesis of defined peptides, portions  
11 of which optionally can consist of redundant known or  
12 unknown (uncharacterized or non-defined sequence) mixtures  
13 which are bonded in micromolar amounts in defined arrays  
14 with known addresses so that a physical barrier (e.g. an  
15 appropriately apertured member) can permit simultaneous  
16 screening. Another feature is fluorescent or radio-  
17 labeled detection of binding, which provides higher  
18 sensitivity and is far more suitable for detection of low  
19 affinity interactions than the current Selectide or Iterex  
20 technology. The solid array support also permits  
21 inference of optional binding elements (e.g. AA sequences)  
22 from the spatial position (unique address) rather than  
23 requiring chemical determination of sequence.

24 The ASBCLs and ASPCLs constructed by the method and  
25 system of this invention are selectively variable at any  
26 two or more positions, while redundant (random selection  
27 of all combination) at several other positions (say, 3-6)  
28 within peptides or biopolymers of a wide range of size and  
29 structure. The system is also useful for screening  
30 (probing) by itself, or in conjunction with current  
31 methods (such as the Iterex Tea-Bag or Selectide methods),  
32 for any two or more AA position sequencing, and can be  
33 used for progressive refinement of initially identified  
34 hits (indications of activity). Because of the  
35 effectiveness of the support system of this invention, the  
36 separate zones (one or more support address area(s)) can  
37 be functionalized for synthesis of peptides at loadings as  
38 low as about .001 micromoles per cm<sup>2</sup>, usually in the range  
39 of from about .05 to about 50μ mole/area, and 50-100 nmole

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1 loading for HPMP winks.

2 The system also permits simultaneous or sequential  
3 synthesis by standard Fmoc or t-Boc-chemistry of  
4 identified areas (addresses) of distinct known or non-  
5 defined peptides, by attaching the slotted block to the  
6 substrate plate for simultaneously performing individual  
7 separate couplings in the slot compartments. By  
8 transforming the block orientation, arrays of peptides may  
9 be synthesized at any two positions within a peptide or  
10 biopolymer of any length. The previous or following Aas  
11 in the peptide sequence may be uniform across the entire  
12 substrate surface, and may be unique or consist of  
13 mixtures of one or more peptides of known or  
14 uncharacterized composition. Common steps can be carried  
15 out in the vacuum block system, and winks loaded with  
16 random peptides may be prepared in an automated peptide  
17 synthesizer.

18 While the same block is shown used in different  
19 orientations, e.g. rotating a slotted block 90°, two  
20 dissimilar blocks may be used in the array generating  
21 steps, such as a radial slot block (slots extending  
22 radially outwardly from a common center) in combination  
23 with a block with concentric circular (annular) slots, and  
24 the resultant array may be addressed by polar coordinates.

25 The system of the invention permits displacing the  
26 label on the target with a natural ligand to insure  
27 specificity of the identification. It also permits reuse  
28 of the substrate for repeated probing of the surface by  
29 alternative proteins i.e. exposure to different targets  
30 followed by washing. DMF washing is particularly easy by  
31 use of the vacuum block where the wash is removed by  
32 aspiration through the vacuum base. Different areas  
33 (addresses) may employ the same or different binding  
34 materials, e.g. Pepsyn K particles in one area, winks in  
35 another, and grafted films in another.

36 Although the method and apparatus shown herein are  
37 directed to definition of optimal binding linear  
38 hexapeptides, it has great applicability in different  
39 formats. Especially where the protein of interest, e.g.



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1 cytokine receptor, binds a large ligand, then it is  
2 advantageous to insert the library within longer  
3 sequences, particularly those which are known to form  
4 stable secondary structures, as in loops, beta  
5 conformations or alpha helices. In the latter, since the  
6 library is then displayed on a cylindrical surface, it is  
7 of interest to construct the components 3 or 4 residues  
8 apart, the components being separated by helix-forming  
9 residues, such as alanine. For libraries based on loop  
10 structures, either end may be designated as a Cys residue  
11 which can then be coupled together by intramolecular  
12 disulfide bridges. Cyclic peptides, especially cyclic  
13 hexapeptides and cyclic decapeptides can be constructed on  
14 PILOT substrate matrices of this invention, and are  
15 especially useful for the relative rigidity of these  
16 molecules compared to their linear counterparts. Also,  
17 bogus pseudo array checking can be easily done with the  
18 system of this invention.

19 The novel PILOT ASBCL's and methods of this invention  
20 provide distinct advantages over the numerous alternatives  
21 discussed above in the Background to meet the need for  
22 developing new pharmaceutically useful compounds. The  
23 specificity of the binding may be uniquely established by  
24 side-by-side comparative processing of dual plates which  
25 are then probed, one with the presence of the natural  
26 ligand, the other without, and the two compared.

27 One particular advantage of the invention is that it  
28 allows detection by numerous methods, but it is unique in  
29 being suitable for detection with radiolabelled  
30 derivatives, with autoradiographic and counting methods  
31 providing the enhanced sensitivity vital for the detection  
32 of relatively low-affinity binding peptides which are  
33 present in picomolar amounts within pools containing  
34 thousands of other non-binding sequences. Use of  $^{125}\text{I}$   
35 labeling with Bolton-Hunter reagent provides sensitive and  
36 simple detection by auto radiography. With  $^{35}\text{S}$  and  $^{14}\text{C}$   
37 labeling, arrays are recoverable and can be reprobbed  
38 numerous times after scintillation counting of individual  
39 winks pushed out of the carrier (holding) plate.

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1 Another advantage of the invention is that it allows  
2 for the use of standard substrate materials (e.g. HPMP  
3 winks or Pepsyn K for peptide synthesis, and HPMP winks or  
4 controlled pore glass for DNA/RNA synthesis), for  
5 synthesis on the plates, or for preassembly by automated  
6 synthesizers followed by arraying these for diagnostic  
7 applications. In library applications, the unique method  
8 of grafting in-situ generated polymers or attaching  
9 preformed polymers to functionalized polyolefin surfaces  
10 such as winks provides materials far better suited for  
11 screening methods than conventional particulate solids.  
12 A special virtue is the optical clarity of the HPMP film  
13 substrates of this invention, combined with their low  
14 intrinsic fluorescence which greatly enhances the  
15 sensitivity when used with fluorescent tags. Of even  
16 greater importance is that the substrate HPMP films of  
17 this invention are formulated to provide excellent  
18 penetration of proteins within their bounds, and side-by-  
19 side comparisons with prior art methods have shown  
20 significantly enhanced sensitivity with use of this  
21 invention.

22 This invention is unique in being suitable for  
23 construction of libraries containing monomer units of  
24 almost any kind, for example, bound together by ether,  
25 thioether, ester, amine, phosphate, amide or any such bond  
26 establishable by organic chemistry methods.  
27 Identification is performed solely through spatial  
28 recognition, and does not require sequencing, which is  
29 generally impossible with other than natural peptide and  
30 DNA units.

31 The PILOT ASBCL's and methods of this invention, are  
32 therefore unique, simple, generally applicable and readily  
33 duplicated. They provide high sensitivity detection by a  
34 variety of tagging procedures.

35 It is important to the application of the PILOT  
36 system of this invention as a general library method to  
37 equally incorporate amino acids from mixtures of Fmoc-  
38 amino acids. We have found that differences in  
39 incorporation diminished with increasing concentration,

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1 and D-derivatives coupled at rates essentially the same as  
2 their L-counterparts.

3 However, rather than use the Rutter-Santi method of  
4 employing concentrations based on the coupling constants  
5 of the amino acids, we use a non-theoretical, empirical  
6 method of determining the molar ratios for equal  
7 incorporation of Fmoc-Amino acids from mixtures. These  
8 mixtures are used to prepare the random  $X_n$ -peptides. We  
9 employ 16 AA's to form a standard mixture,  $\Omega$ . As used  
10 herein, Mix = Mix, (Mix)<sub>2</sub> or  $\Omega$ -2 refers to two reaction  
11 cycles with the  $\Omega$  mixture.

12 Based on Example 1 below, the molar ratios described  
13 in Table 1 below give substantially equal incorporation on  
14 HPMP winks as confirmed by both amino acid analysis and  
15 sequencing. Sixteen amino acids are incorporated in our  
16 standard mixture  $\Omega$ . Mixtures may be incorporated at 6 or  
17 more positions in a core sequence, and "arrayed" at any  
18 other two or more positions. Bogus arrays may be  
19 constructed using conventional peptide synthesizers.  
20 Study of non-arrayed mixed winks in the presence and  
21 absence of natural ligand(s) shows whether a detailed  
22 array study will be able to uncover binding sequences.  
23 The molar ratios of Table 1 are obtained by coupling, AA's  
24 selected with 1.25 equivalents HOBt + 1.5 equivalents  
25 PyBOP and 1.5 equivalents 0.3M NMM in DMF after 10 minutes  
26 preactivation.

27 Table I

28 Molar Ratios For Equal Incorporation of  
29 Fmoc-Amino Acids From Mixtures

32 Fmoc- 33 Derivative	34 Molar Ratio	Fmoc- Derivative	Molar Ratio	Fmoc- Derivative	Molar Ratio
35 L-Nle*	1.00	L-Ala*	0.79	D-Nap*	1.50
36 L-Leu	1.00	L-Ser(tBu)*	1.50	L-Tyr(Tbu)*	1.70
37 L-Val*	1.60	L-His(Trt)*	2.10	L-Phe*	1.00
38 Gly*	0.60	L-Gln(Trt)*	2.20	L-Asp(OtBu)*	1.40
39 D-Ala*	0.79	L-Pro*	1.15	L-Glu(OtBu)*	1.20
40 L-Lys(tBoc)*	1.36	L-Arg(Pmc)*	3.00	L-Thr(Tbu)	2.00
41 L-Asn(Trt)	2.45				

42  
43  
44 "Nap" is 3-(2-naphthyl)-alanine; the 1-naphthyl derivative  
45 couples similarly. The AAs marked with \* are used in the  $\Omega$  mixture.  
46  
47  
48

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1     **DRAWINGS:**

2             Fig. 1 is an isometric view of an assembled PILOT  
3     slotted block system apparatus, partly broken away to show  
4     the various parts in proper alignment and ready for  
5     introduction of AA's for reaction with the substrate areas  
6     or moieties thereon;

7             Figs. 2a and 2b are section views taken in elevation  
8     along line 2-2 of Fig. 1 showing two alternative  
9     structures of a substrate area in detail;

10            Fig. 3 illustrates using a combination of two  
11     different blocks, one radial and one with concentric  
12     annular slots, with a circular support plate to produce a  
13     circular array;

14            Fig. 4 is a section view of the concentric annular  
15     block taken along line 4-4 of Fig. 3;

16            Fig. 5 is an isometric view of the peripheral frame  
17     system of this invention for functionalizing plates prior  
18     to condensing biopolymers thereon;

19            Fig. 6 shows in exploded isometric view the presently  
20     preferred embodiment of the slotted block assembly of Fig.  
21     1 employing a vacuum disc-holding array plate for the  
22     array preparation steps;

23            Fig. 7 shows in exploded isometric view the use of  
24     the vacuum plate on the vacuum base for common peptide  
25     synthesis and probing steps;

26            Fig. 8A is an enlarged vertical section view through  
27     one hole of the vacuum block with a single vacuum draw and  
28     drain hole below the sintered disc "wink" in place in an  
29     array hole;

30            Fig. 8B is a vertical section-view through an  
31     alternate embodiment of the vacuum plate with multiple  
32     vacuum/drain holes;     Fig. 9 shows in isometric a  
33     slotted gasket used above the plates of Figs. 1, 6 and 7  
34     in place of the multi-hole array gasket 10 of Figs 1 and  
35     5;

36            Fig. 10 is a graph of the percent amino acid vs.  
37     molar percent incorporation in equi-molar mixtures to  
38     prepare the  $\Omega$  mixtures used herein; and

39            Fig. 11 shows the results of the  $^{35}\text{S}$  streptavidin

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1 array test.

2

3 **DETAILED DESCRIPTION OF THE BEST MODE OF THE INVENTION:**

4 The following detailed description illustrates the  
5 invention by way of example, not by way of limitation of  
6 the principles of the invention. This description will  
7 clearly enable one skilled in the art to make and use the  
8 invention, and describes several embodiments, adaptations,  
9 variations, alternatives and uses of the invention,  
10 including what we presently believe is the best mode of  
11 carrying out the invention.

12 Referring to Fig. 1 the slotted block system of this  
13 invention 1 includes a square base 2 which has or receives  
14 orienting members, such as a plurality of guide and  
15 securing rods 3 with wing nuts 4. The square base 2  
16 receives a square substrate support plate 5 which includes  
17 an array of areas 6. There are three basic variations in  
18 the substrates: in situ beads, film, or discs as shown in  
19 Figs. 2a, 2b and 8a/8b, respectively.

20 In a first, embodiment shown in Fig. 2a, each area 6  
21 includes substrate 7 (in this case beads) secured in  
22 depression 8 by a suitable glue 9. The second embodiment  
23 of Fig. 2b shows a grafted polymeric film as the substrate  
24 7 in depression 8. Figs. 8a and 8b show the porous  
25 sintered polyolefin HPMP coated disc, which is the  
26 presently preferred embodiment.

27 Overlying the substrate support plate 5 is a square  
28 gasket 10, preferably a sheet of chemically inert  
29 elastomeric material (e.g., Viton or silicon rubber),  
30 having an array of holes 11 therethrough which are the  
31 same size as and in alignment with the substrate areas 6.  
32 See Figs. 1, 2a, 2b, 3, 6 and 9. The gasket functions to  
33 prevent leakage between individual substrate areas 6 or  
34 discs 50. An alternative slotted gasket 10a, shown in  
35 Fig. 9 may be used in place of multi-holed gasket 10, but  
36 it must be rotated with the slotted block 12. The slotted  
37 gasket 10a may be glued to the underside of the slotted  
38 block 12. Still another alternative is to provide O-  
39 rings, one per array area, in a groove concentrically

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1 surrounding each area. Or a groove can be provided on the  
2 underside of each slotted block surrounding each slot,  
3 which groove receives a round (in cross-section) seal  
4 strip.

5 A square slotted block 12, having holes 13  
6 therethrough to receive the guide/securing rods 3 is  
7 placed over the gasket 10. This block 12 includes a  
8 plurality of slots 14, 15, 16 etc. therein, which are  
9 aligned with and extend a full row width of the substrate  
10 areas 6. The slots may be identified, as by the alpha  
11 designations A,B,C etc. shown. Note in the substrate  
12 support plate 5, additional corresponding rows L,M,N...  
13 are shown. In a typical block 12, there will be some 4 to  
14 10 and as many as 400 such slots. Fastening the wingnuts  
15 4 secures the assembly together in the proper orientation  
16 and prevents leakage between adjacent slots and substrate  
17 areas when individual reaction solutions are placed in the  
18 wells formed by the slots. Fig. 6, the presently  
19 preferred embodiment in which the wink carrier plate 5' is  
20 used, employs the same top gasket 10, but uses a hole-less  
21 bottom gasket 49 to seal between adjacent holes.

22 Continuing with Fig. 1, after reaction, removal of  
23 solution, washing and deprotecting, the square block 12 is  
24 rotated by 90° and selected solutions are introduced in  
25 the chosen slots, to produce a known array of dipeptide  
26 sequences. This cycle can be carried out with the  
27 apparatus of Fig. 6 as well.

28 Fig. 3 shows an important variation involving a round  
29 substrate support plate 20 having a concentric/radial  
30 array 21 of discrete substrate areas or holes 6. A gasket  
31 22 also includes a corresponding concentric/radial array  
32 of holes 23. In this embodiment, two slotted plates may  
33 be employed sequentially: slotted radial plate 24, and  
34 concentric slotted plate 25, in either sequence, 24, 25 or  
35 25, 24. There may be fewer radial slots 26 than the  
36 radial array of holes 23 or substrate areas 21, in which  
37 case the block 24 may be turned between application of  
38 reactants (e.g., AA solutions). The inner concentric  
39 segments 27, 28, 29 etc. may be secured in spaced

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1 relationship by horizontal rods 30, 31, which are spaced  
2 above the bottom 32 of block 25 to insure access of  
3 solution to all relevant substrate areas. In Fig. 2 the  
4 base plate and pins are omitted for clarity.

5 Fig. 4 shows in vertical cross section the  
6 construction of the concentric slotted plate 25 in which  
7 outer ring 27 is spaced from inner core 34 by rod 31. A  
8 series of tubular spacers 35, 36, 37, 38 on rod 31 space  
9 the concentric intermediate rings 28, 29 from core 34 to  
10 provide concentric annular slots. The rod 31 may be  
11 countersunk in bore 39.

12 Figs. 5 and 7 show a border frame assembly for  
13 functionalizing the substrate areas 8 on support plate 5,  
14 e.g., with common Aas, or mixtures of Aas, and for  
15 deblocking, washing, probing (screening) and addition of  
16 spacer arm derivatives. An edge gasket 40 is placed on  
17 the substrate plate 5, then a border frame 41 is placed  
18 thereover and secured with clamps 42, 43. This provides  
19 a central well 45 for the entire array for simultaneously  
20 receiving the appropriate solutions for the  
21 functionalizing chemistry.

22 Fig. 7 shows a border frame assembly in association  
23 with a vacuum base 46. In this embodiment the wink  
24 carrier plate 5' is sandwiched between two identical edge  
25 or periphery gaskets 40a, 40b and placed on vacuum base 46  
26 having a trough-shaped interior cavity 47 and an  
27 aspiration outlet tube 48. The border frame 41 is placed  
28 on top of gasket 40a and the entire assembly clamped  
29 together, by rods 3 through holes 13 which are secured by  
30 wingnuts 4. This is the preferred assembly for common  
31 steps, e.g., of adding the previously determined or  
32 selected di-, tetra-, hexa-, etc, peptides and for  
33 deprotecting, washing and probing. The tube 48 is  
34 connected to a vacuum source, such as a water aspirator,  
35 which sucks excess or spent solution through the porous  
36 granular sintered winks (see Figs. 8a and 8b) and out  
37 trough 47.

38 Figs. 8a and 8b are enlarged vertical section views  
39 of the porous HPMP winks 50 which are easily insertable in

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1 holes 51 bored partway through carrier plate 5'. A slight  
2 tapered shoulder 52 permits drainage via hole 53 when  
3 suction is applied from below. The wink diameter is  
4 typically 1/4", and hole 53 is 1/8". Pressure P from  
5 finger 54 is sufficient to press-fit the winks 50 into  
6 holes 5'. A dowel or Q-tip 55 inserted in hole 53 is  
7 sufficient to remove the wink. Fig. 8b shows a variation  
8 in which multiple drain holes 56, 57, 58 etc. may be  
9 employed. A smaller dowel or comb-like pusher may be used  
10 to remove the winks by insertion through holes 56-58.

11 The wink carrier plate 5' securely holds porous  
12 polyolefin discs 50 throughout the course of the array and  
13 probing. Dextranized winks are prepared as described  
14 above. Common unarrayed sequences are assembled on the  
15 winks using commercial synthesizers. They are then  
16 mounted in plate 5' as shown in Fig. 8a. To directly  
17 perform an array the plate is mounted in the slotted block  
18 apparatus of Fig. 6 with a solid viton gasket 49 between  
19 it and the base plate, and a regular holed gasket 10  
20 placed between the plate 5' and the slotted block 12.  
21 Coupling of one dimension of the array is then performed.  
22 The plate is then transferred to and secured in the vacuum  
23 base apparatus of Fig. 7, along with edge gaskets 40a and  
24 40b, and the window frame block 41, and washed with DMF  
25 (e.g., shaken with DMF for 30 seconds) then the wash is  
26 removed by aspiration through the base 46. This washing  
27 is extremely efficient in comparison to the bath technique  
28 of Fig. 1. This is followed by Fmoc removal steps  
29 (deprotection), and more washings performed analogously.  
30 The second dimension of the array may then be performed,  
31 or common sequences introduced, as required. Following  
32 assembly of the array, the completed plate mounted in the  
33 vacuum block of Fig. 7 is treated with TFA + scavengers to  
34 remove side-chain protection. Following washing with  
35 methanol, DMF and water, the plate is then washed and  
36 thoroughly equilibrated with assay buffer. The radio-  
37 labelled protein is then introduced, and the plate probed  
38 as appropriate (10 minutes to 2 hours). A parallel plate  
39 produced in a second apparatus of Fig. 7 can be used to



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1 simultaneously determine the specificity of binding (i.e.,  
2 by addition of natural ligand). After incubation, the  
3 plate 5' is suction washed rapidly with 4 additions of  
4 buffer (20 Ml), removing unbound label. Binding may be  
5 determined by autoradiography. With weaker isotopes, the  
6 individual winks may be punched into scintillation vials  
7 and counted. This is a simple and quantitative procedure.  
8 Of great importance, we have found that, in a variety of  
9 cases, the winks can be recovered, the radioactivity  
10 displaced, and the winks reused for similar or different  
11 assay purposes. The reusability of the system is one of  
12 its key attributes.

13 The following example protocols describe the  
14 sequential steps of the method:

15

16 **Example 1 - Determination of AA Mixture Proportions for**  
17 **Equimolar Incorporation on Substrates - Empirical**  
18 **Method:**

19 The component amino acid (Fmoc-X-OH, 1 equivalent) is  
20 mixed with Fmoc-Nle-OH (1 equivalent), then dissolved and  
21 activated by the addition of PyBOP, HOBT and NMM  
22 solutions. After 10 minutes the mixture is added to Nva-  
23 PAL-Pepsyn K support (5 mg). After 2 hours the support is  
24 washed with DMF repeatedly, treated with 30% piperidine in  
25 DMF (to remove incorporated Fmoc- groups), washed with  
26 DMF, and methanol, then treated with TFA/water (95:5) for  
27 2 hours. The TFA solution is expelled into a vial, a known  
28 proportion of it dried down in vacuo, and the resultant  
29 mixed dipeptides X-Nva and Nle-Nva are hydrolysed with 6M  
30 Hcl at 150 degrees for 1 hour. The relative incorporations  
31 of X and Nva are then determined by amino acid analysis.

32 A graph is constructed plotting molar % X (in this  
33 initial round X is 50%) against molar percentage  
34 incorporated; and the curve which results when using  
35 extremities points at 0 and 100% is used to predict what  
36 molar percent X would give equal incorporation to that of  
37 Nle. The molar percent incorporation of an individual  
38 amino acid is the amount of the amino acid divided by the  
39 sum of the amino acid + Norleucine + Norvaline (i.e.,

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1 AA/(AA + NLE + NOR) = % incorporation). As shown in Fig.  
2 10 the molar percent incorporation is then plotted against  
3 the percent amino acid in the mixture. The zero and 100%  
4 data points are also included. Draw a line from the 50  
5 percent point on the y-axis to the curve and then drop a  
6 line from that point to the x-axis and determine the  
7 percent molar incorporation necessary to obtain a 50  
8 percent amino acid mix. In this example, the first  
9 evaluation was made with 50% Asparagine and 50%  
10 Norleucine. This gave a mixture of approximately 30%  
11 Asparagine and 70% Norleucine. A refined evaluation was  
12 made with 67% Asparagine which gave a mix of 45%  
13 Asparagine/55% Norleucine. The final value was determined  
14 to be 71% Asparagine to achieve a 50% mix.

15 The process is repeated using the predicted molar  
16 percent X to confirm and, if necessary, iteratively refine  
17 the molar percent. This method has been applied to all 20  
18 natural L-amino acids, most D-amino acids, and several  
19 unnatural amino acids, such as beta-alanine and 2-  
20 naphthylalanine.

21 For any desired library mixture, the amino acids are  
22 selected, mixed in the correct ratios, activated, coupled  
23 to the support, and the equal incorporation confirmed by  
24 analysis. For the 10 amino acid library the subject of  
25 these examples the following recipe gives equal  
26 incorporation: Fmoc-L-Nle-OH 0.188g; Fmoc-L-His(Trt)-OH  
27 0.73g; Fmoc-L-Pro-OH 0.24g; Fmoc-L-Gln(Trt)-OH 0.797g;  
28 Fmoc-L-Tyr(Tbu)-OH 0.398g; Fmoc-Gly-OH 0.093g; Fmoc-L-Phe-  
29 OH 0.206g; Fmoc-L-Arg(Pmc)-OH 1.25g; Fmoc-L-Glu(OtBu)-OH  
30 0.288g; and Fmoc-D-Ala-OH 0.130g. To these mixed amino  
31 acids were added HOBt 1.614g, and the entire solids  
32 totally dissolved in DMF and made up to a volume of 40 Ml.  
33 For coupling, 10 Ml of this solution, called MIX solution,  
34 is added to 1.71g PyBOP reagent, mixed, 0.35 Ml of N-  
35 methylmorpholine is added, remixed and left for 10  
36 minutes. This solution is adequate to completely cover and  
37 react a single 10 x 10 plate giving equal incorporation.  
38 Table I and its related description above show the  
39 quantitative amounts in this example converted to molar

1 ratios.

2

3 **Example 2 - Preparation of A "Beaded" Plate (Support Plate**  
4 **With Array of Bead-Type Substrate Areas):**

5 The sequence BAla-Bala-Bala-Nle-Bala-Nle-Bala-Bala  
6 was assembled on 0.2 mmol/g Pepsyn-K (Millipore)  
7 functionalized by treatment with ethylenediamine using a  
8 Milligen/Biosearch model 9600 peptide synthesizer using  
9 standard BOP + HOBT coupling protocols. Ace Hardware Hot  
10 Melt adhesive was cut into thin sections and melted at as  
11 low a temperature as possible on a flat PTFE sheet to  
12 produce a thin sheet (in a range of from about .2 to about  
13 1.0mm thick) of hot melt adhesive (HMA sheet). The PTFE  
14 sheet was removed from the heat, and dry, peptide-bearing  
15 Pepsyn-K beads were sprinkled over the melted glue surface  
16 and gently patted down. After several hours of cooling,  
17 excess beads were removed and the glue sheet lifted off  
18 the PTFE sheet, then punched into appropriate circles  
19 (e.g. 1-10mm dia) with a standard hole punch. The  
20 resultant discs were then attached to an array of shallow,  
21 dished wells in a polyethylene sheet using a Black and  
22 Decker Thermogrip glue gun adding a dab of glue in the  
23 well and pushing the discs down firmly. The discs can be  
24 reinforced with polypropylene or metal mesh. Typically,  
25 each patch bears 5 mg of beads, having 1 micromole of  
26 spacer arm linked Pepsyn-K. The top right hand corner of  
27 every plate is notched or drilled as a reference to  
28 prevent the plate being incorrectly aligned at any step.

29

30 **Example 3 - A Preparation of A Polymeric "Film" Plate:**

31 A 10mm thick plate of linear high density  
32 polyethylene is floated in a water bath at 70°C and treated  
33 with 5M chromium trioxide in 5.3M sulfuric acid for two  
34 hours. The plate is washed with water many times, then  
35 with methanol, and then with ether, and dried under  
36 vacuum. The surface bound carboxylic acids are converted  
37 to acid chlorides by treatment with 20% thionyl chloride  
38 in chloroform for two hours. The plate is rapidly washed  
39 with chloroform, then ether, and dried under a stream of

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1 nitrogen and used immediately. This acid chloride  
2 functionalized plate can be derivatized by a variety of  
3 reagents to introduce many functionalities. Linear  
4 polymers, such as polyethylenimine, and  
5 poly(amino)functionalized polyethylene glycols, and  
6 saccharide may be added to the plates by conventional  
7 chemistries. For example, for introduction of acryloyl  
8 groups, the plate may be treated with either a solution of  
9 N-(3-aminopropyl) methacrylamide hydrochloride and  
10 triethylamine in DMF, or it may be treated with neat  
11 (undiluted) diaminopropane for two hours, followed by  
12 washing thoroughly with water, then methanol, then ether,  
13 and then treated with a solution of acryloyl chloride and  
14 diisopropylethyl amine in THF. The plate is washed well  
15 consecutively with methanol and ether, and dried under  
16 vacuum. The plate is now ready for grafting or casting of  
17 a gel film thereon as the substrate in the specific  
18 address areas.

19 The gels which may be cast into the wells of the  
20 substrate plate or grafted to the acryloyl groups on the  
21 surface of a film plate can have a variety of  
22 concentrations, cross-linking levels, functional linkers  
23 and amino linker loading. To prepare a typical gel, under  
24 nitrogen, a 5 ml portion of deoxygenated water (under  
25 vacuum for 20 minutes) is added to 18.5 mg of  
26 bisacryloyldiaminohexane, 295 mg of dimethylacrylamide,  
27 and 186 mg of the monoacrylamide of 1,6 diaminohexane  
28 hydrochloride. This is filtered onto 15 mg of ammonium  
29 persulfate and treated with 30 uL of Ph 6 TEMED solution  
30 in water. In a glove bag under nitrogen, the monomer  
31 solution is rapidly transferred to each well of the plate.  
32 The plate is sealed in a plastic bag with an open beaker  
33 of deoxygenated water and allowed to gel. After curing  
34 over night the plate is washed with water and soaked in 1N  
35 sodium hydroxide for 2 hours. Two water washes of 15  
36 minutes each followed by at least four washes in DMF give  
37 a plate which is ready for peptide synthesis.

38

39 Example 4 - Spacer Arm Derivatization of The Film:

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1        Optionally a gel film plate of the type in Example 3  
2        may have a tetrapeptide spacer attached to the substrate.  
3        A plate prepared as in Example 3 had Fmoc-beta-alanine  
4        (Bala) coupled to it (standard PyBOP + HOBT/MMM procedure,  
5        2 hours). Following thorough DMF washes, the plate was  
6        treated with 30% piperidine in DMF (1, 45 minutes). The  
7        plate was washed 2 times with DMF, and the piperidine  
8        treatments and subsequent washes were pooled and read  
9        spectrophotometrically at 301 nm to determine the Fmoc-  
10       loading (in this example 2 micromoles per substrate area).  
11       Three more coupling cycles were then performed adding  
12       Fmoc-epsilon-aminocaproic acid twice, then beta-alanine  
13       again to give the final Bala-Aca-Bala spacer arm film  
14       plate as used in the preferred embodiment for ASBCL or  
15       ASPCL libraries.

16

17       **Example 5 - Construction of A 10x10 Hexapeptide ASPCL**  
18       **Plate:**

19       The method of this invention allows the construction  
20       of arrays of sequences at any 2 sequence positions within  
21       peptides of any reasonable size with several positions  
22       being incorporated as mixtures. The preferred embodiment  
23       of the method is to prepare hexapeptides with the central  
24       2 AA's arrayed, the other 4 positions redundantly mixed,  
25       and the final sequence AA is N-acetylated. For film  
26       plates it is preferred to add a spacer arm peptide to the  
27       film prior to construction of the library, and with beaded  
28       plates an octapeptide spacer is attached prior to  
29       embedding in the glue. The following sequence of  
30       operations is followed to prepare a Hexapeptide ASPCL with  
31       a known central (3,4) AA sequence:

- 32       i)    Apply an edge gasket and a border-frame spacer  
33            on the substrate plate (see Fig. 5) to make a  
34            flat "dish" type reactor. As an alternative to  
35            use of the screwed pin base plate assembly of  
36            Fig. 1, one may use standard large office clips,  
37            or wing nuts and standard bolts and washers to  
38            hold the parts together;  
39       ii)   Wash with DMF 2x using horizontal action shaker;

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- 1       iii) Couple 10 Ml preactivated MIX solution made as
- 2             per Example 1 for 2 hours, while covering plate
- 3             with foil tent;
- 4       iv) Wash with DMF 3x;
- 5       v) Deblock with 30% piperidine in DMF 1 min, 10
- 6             min;
- 7       vi) Wash with DMF 5x;
- 8       vii) Repeat steps iii) to vi);
- 9       viii) Dismount edge gasket and frame spacer, and
- 10            mount slotted block assembly with 100 hole
- 11            gasket to base plate as in Fig. 1 with slots
- 12            in a first, horizontal orientation (L TO R
- 13            when facing the assembly). DMF solvent is
- 14            placed in alternate wells and the dry wells
- 15            observed carefully to ensure no leakage.
- 16            Prepare in vials the following amino acids: 1.
- 17            Fmoc-L-Nle-OH 0.14g; 2. Fmoc-L-His(Trt)-OH
- 18            0.25g; 3. Fmoc-L-Pro-OH 0.135g; 4. Fmoc-L-
- 19            Gln(Trt)-OH 0.244g; 5. Fmoc-Tyr(Tbu)-OH
- 20            0.163g, 6. Fmoc-Gly-OH 0.116g; 7. Fmoc-L-Phe-
- 21            OH 0.154g; 8. Fmoc-L-Arg(Pmc)-OH 0.265g; 9.
- 22            Fmoc-L-Glu(OtBu)-OH 0.17g; 10. Fmoc-D-Ala-OH
- 23            0.124g. To each of these vials add and mix
- 24            PyBOP 0.27g and HOBt 0.06g, and 2 Ml of 0.3M
- 25            N-methylmorpholine in DMF. Add each to a
- 26            designated horizontal slot: 1 to top slot; 2
- 27            to next slot, etc.;
- 28       ix) Maintain at room temperature for 2 hours to
- 29            complete coupling;
- 30       x) Disassemble and remount with edge-gasket and
- 31            border-frame spacer;
- 32       xi) Wash with DMF 3x;
- 33       xii) Deprotect with 30% piperidine in DMF 1 minute,
- 34            10 minutes;
- 35       xiii) Wash with DMF 5x;
- 36       xiv) Mount slot block with slots rotated 90°, i.e.,
- 37            in a vertical orientation, and repeat coupling
- 38            as described in viii) except 1 is coupled to the
- 39            left hand slot, 2 to the next slot, etc.;

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- 1        xv) Disassemble and remount with edge-gasket and  
2        border-frame spacer;  
3        xvi) Remove Fmoc group and perform 2 cycles of  
4        mixture incorporation as described in i) to  
5        vii);  
6        xvii) Remove Fmoc-group and wash with DMF 5x;  
7        xviii) Acetylate with 0.3M acetic anhydride + 0.3M  
8        HOBT in DMF (10 Ml) for 1 hour;  
9        xix) Wash DMF 5x, Methanol 5x;  
10      xx) Treat with 95:5 TFA/water for 2 hours;  
11      xxi) Wash Methanol 5x, aqueous buffer 5x. Store in  
12      sealed bag at 4 degrees prior to probing to  
13      screen a target.

14      Numbering from the carboxy terminus, the resulting  
15      hexapeptides are characterized as XX-A<sub>4</sub>, A<sub>3</sub>-XX with the A<sub>3</sub>  
16      and A<sub>4</sub> known sequence being uniquely addressable. That is,  
17      the central dipeptide is known from its unique address by  
18      use of the slotted block, the hexapeptide at address 001  
19      being XX-D-Ala-L-Nle-XX, at address 002 being XX-L-Glu-L-  
20      Nle-XX, etc., to address 100 being XX-L-Nle-D-Ala-XX.

21

22      **Example 6 - Construction of A 10x10 Hexapeptide ASPCL on**  
23      **a Gel Film Plate**

24      Instead of a bead plate, a gel film plate as in  
25      Examples 3 and 4 may be similarly employed to construct an  
26      ASPCL library by the process of Example 5. This gel film  
27      ASPCL is used to screen, see Example 7 below.

28

29      **Example 7 - Determination of Binding Elements in the**  
30      **Interaction of Streptavidin with Peptides**

31      A film library plate of Examples 3 and 4 was  
32      constructed similarly to Example 6 with the selection of  
33      10 amino acids as indicated. <sup>125</sup>I labelled streptavidin  
34      was prepared and purified by standard procedures; a  
35      fluorescently labelled form was also prepared by reaction  
36      of AMCA-NHS (Pierce) with the protein, excess reagent  
37      being removed by dialysis. Firstly, the iodinated protein  
38      was incubated with the plate overnight in a phosphate  
39      buffer containing 150 Mm salt, Tween detergent and bovine

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1 serum albumin (1mg/ml). The plate was washed with the  
2 buffer 3 times, placed on a standard laboratory X-ray film  
3 with an enhancer plate and exposed overnight. The  
4 developed film shows strong affinity in specific address  
5 locations corresponding to 2 central dipeptides HP and RR.  
6 The plate was then washed repeatedly with 6M guanidine  
7 hydrochloride, and buffer medium, then reincubated with  
8 the fluorescent AMCA-streptavidin overnight. After  
9 washing the plate was irradiated with long wave length uv  
10 light and visible confirmation obtained of the previously  
11 deduced binding elements. Subsequent iterations as  
12 described above further defines the active dipeptides at  
13 each end for complete hexapeptide characterization.

14

15 **Example 8 - Array Test for <sup>35</sup>S Streptavidin Using HPMP**  
16 **Winks in a Carrier Plate**

17 This example details the use of the HPMP winks in the  
18 carrier plate 5' of Fig. 8a with the slotted block system  
19 of Fig. 6 and vacuum base system of Fig. 7.

20 70 dextran functionalized winks were placed in the  
21 reaction vessel of a Millipore Model 9600 peptide  
22 synthesizer. A mixture of Fmoc-protected amino acids was  
23 made by carefully weighing the individual components  
24 according to the following list, followed by intimately  
25 mixing them in a pestle and mortar: L-NorLeu, 0.093g; L-  
26 His(Trt), 0.341 g; L-Pro 0.10g; L-Gln(Trt), 0.351g; L-  
27 Tyr(Tbu), 0.203g; Gly, 0.046g; L-Phe, 0.102g; L-Arg(Pmc),  
28 0.52g; L-Glu(OtBu), 0.132g; L-Ala, 0.064g; D-Ala, 0.064g;  
29 L-Asp(OtBu), 0.150g; L-Val, 0.131g; L-Ser(Tbu), 0.149g; D-  
30 (2-naphthyl)Ala, 0.153g; L-Lys(Tboc), 0.168g. Four  
31 individual aliquots of the mixture (0.461g) were placed  
32 along with PyBOP (0.82g) and HOBt(0.2g) in each of the  
33 first 4 reservoirs of the instrument, and synthesis  
34 performed using standard Fmoc 4 hour coupling programs  
35 with 10 minute preactivation.

36 Following synthesis, 64 of the product winks, now  
37 bearing tetrapeptide mixtures of all possible  
38 combinations, were placed in an 8x8 array in the standard  
39 10x10 plate with blank winks occupying peripheral



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1 positions. The plate was marked in its top right hand  
2 corner, washed with DMF several times, then placed in the  
3 slotted block system of Fig. 6 with a solid viton gasket  
4 between it and the base plate. The standard 100 hole top  
5 gasket was then positioned, followed by the slotted block  
6 in a vertical orientation. The slots were tested to make  
7 sure no leakage was occurring. For array coupling, pairs  
8 of amino acids were added to the 8 appropriate slots as  
9 follows (each pair also had added 0.80g PyBOP and 0.2 g  
10 HOBt, activation was with 5 ml of 0.3M NMM in DMF): Slot  
11 2, Tyr(Tbu) 0.29g + Phe 0.143g; Slot 3, Asp(OtBu) 0.22g +  
12 Glu(OtBu) 0.195g; Slot 4, Arg(Pmc) 0.457g + Lys(Tboc)  
13 0.145g; Slot 5, Nle 0.134g + Val 0.21g, Slot 6, Gly 0.128g  
14 + D-Ala 0.177g; Slot 7, Ala 0.109g + Ser(Tbu) 0.249g; Slot  
15 8, His(Trt) 0.29g + Gln(Trt) 0.312g; Slot 9, Pro 0.146g +  
16 DNaPAla 0.25g. The apparatus was left to gently shake  
17 overnight to insure coupling.

18 The apparatus was disassembled, the plate 5' placed  
19 in the vacuum block assembly of Fig. 7, washed with DMF  
20 (6x), deblocked with 30% piperidine in DMF for 10 minutes,  
21 washed DMF (6x). Plate 5' was placed back in the slotted  
22 block system of Fig. 6 with the slotted block being turned  
23 90°. An identical array coupling was performed except  
24 that the slots were now oriented in a horizontal manner.  
25 After a 4 hour coupling, the plate 5' was transferred back  
26 to the vacuum base apparatus of Fig. 7, washed with DMF  
27 (6x), deblocked with 30% piperidine in DMF (10 minutes),  
28 then washed with DMF (6x) and methanol (6x). The plate 5'  
29 carrying the winks was then treated to remove all side-  
30 chain protecting groups for 4 hours with 90% TFA, 5%  
31 anisole, 2.5% water, 2.5% dimethyl sulfide. Subsequently  
32 it was washed 6 times with methanol, then DMF, water,  
33 methanol and water. It was then equilibrated overnight in  
34 the assay buffer consisting of phosphate buffered saline  
35 (PBS) containing 0.2% Tween 20 detergent and 1 mg/ml of  
36 bovine serum albumin.

37 To probe the plate, fresh buffer was added (20 ml),  
38 and 100 microliters of standard Amersham <sup>35</sup>S labeled  
39 streptavidin solution added. The probing was rocked

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1 gently for 2 hours, then the supernatant sucked out via  
2 the vacuum base. The plate was then washed rapidly whilst  
3 rocking with 2 x 20 Ml of assay buffer, then 2x 20 Ml of  
4 water. The plate was then separated from the apparatus,  
5 inverted, and individual winks poked (Fig. 8a) out into  
6 clearly labeled corresponding scintillation vials  
7 containing 0.5 Ml of 0.1M Hcl. These vials were shaken  
8 for 1 hour to displace bound activity. Standard  
9 scintillation cocktail (10 Ml) was added, then each vial  
10 counted for 5 minutes on a Beckman beta-counter.

11 Results according to array location are depicted in  
12 Fig. 11. Surprisingly, many areas have absorbed  
13 radioactivity. Four main peaks were selected, and the 16  
14 possible dipeptides (GF, GY, DAY, dAF, NleG, NleDala, VG,  
15 VdA, NleY, NleF, VY, VF, NleNle, NleV, VNle, VV were  
16 produced on (Mix)<sub>4</sub> winks with the aid of a modified  
17 multiple peptide synthesizer. Following side-chain  
18 deprotection and probing, VY and VF showed maximal binding  
19 with >90% of absorbed counts being displaced with biotin.

20 A second array series was then performed. (Mix)<sub>2</sub>  
21 winks were made and mounted in the plate. The array steps  
22 were then performed in the central 2 positions of the  
23 hexapeptide. First Y, then V were added to complete the  
24 process. Deprotection, probing and synthesis of possible  
25 selections found VYGF and VYHP as strong binders.

26 A third array series was then performed with the C-  
27 terminal 2 positions arrayed and VYGF appended thereto.  
28 Probing showed VYGF<sup>RQ</sup> as the best combination. Following  
29 up a VYHPQ lead, we found VYHPQF and VYHPQV to be good  
30 binders, slightly better than HPQFVbA, and our own best  
31 sequence HPQV<sup>FV</sup>. To test whether the two series of  
32 peptides overlapped at the biotin binding site of  
33 streptavidin, a combination nona-peptide, HPQVYGF<sup>RQ</sup>, was  
34 made and found to be a much stronger binder by both  
35 BIAcore and PILOT comparison.

36 This example illustrates the true potential of the  
37 PILOT method for drug discovery. Its high sensitivity,  
38 utilizing arrays prepared by the simple system of this  
39 invention with optimal display chemistry of the HPMP

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1 winks, allows the identification of weak binding elements,  
2 which when combined and properly oriented permit advanced  
3 pattern recognition for mapping of receptors to yield new  
4 highly active drug candidates and high affinity super-  
5 binding compounds.

6 It should be understood that various modifications  
7 within the scope of this invention can be made by one of  
8 ordinary skill in the art without departing from the  
9 spirit thereof. We therefore wish our invention to be  
10 defined by the scope of the appended claims in view of the  
11 specification as broadly as the prior art will permit.

CLAIMS

## We Claim:

1. A biological screening assembly comprising in operative combination:

5 a) an inert support plate having defined thereon an array of discreet, individually addressable areas for receiving a biopolymer-retaining substrate material;

b) at least one biopolymer-retaining substrate material secured to each of said addressable areas; and

10 c) said substrate material on at least some of said areas of said array is selected from the group consisting essentially of a polymer disc, a polymer film, aparticulate material, and combinations thereof, and said substrate material is amino-functionalized for assembly of biopolymer chains thereon.

2. A biological screening assembly as in claim 1 wherein:

5 a) said polymer film on at least some of said areas of said array is selected from the group consisting essentially of a film polymerized in situ, at least partly preformed polymer, and combinations thereof;

b) said plate areas include active groups for chemical bonding with components forming said films; and

10 c) said substrate includes at least one functionalized spacer arm derivative in at least some of said areas.

3. A biological screening assembly as in claims 1 or 2 wherein:

a) said plate is a polyolefin;

5 b) said film is a polymer having low molar percentage of crosslinking covalently grafted to said active groups in said areas to form said biopolymer-retaining substrate; and

c) said spacer arm is amino-functionalized.

4. A biological screening system comprising in

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operative combination:

- 5 a) an inert support plate having defined thereon an array of discreet, individually addressable areas for receiving a biopolymer-retaining substrate material;
- b) at least one biopolymer-retaining substrate material secured to each of said addressable areas.
- 10 c) a barrier gasket sheet overlying said support plate having an array of holes therethrough aligned with said array of areas for access to said substrate areas; and
- 15 d) an apertured block disposed on said gasket having a plurality of slots each oriented to provide a common well for simultaneous access to a plurality of said substrate areas in said array.

5. A biological screening system as in claim 4 wherein:

- a) said array is selected from a rectangular  $N \times N$  array wherein  $N$  ranges from 2 to 400;
- 5 b) said slotted block is selected from a corresponding block having  $N$  linear slots positioned to provide access to all the substrate areas of said plate; and
- 10 c) said block is orientable on said array in at least two rotationally different positions with respect to each other to permit construction of defined sequences from chemical components placed in said wells.

6. A biological screening system as in claims 4 or 5 wherein:

- 5 a) said block includes means for identifying the orientation of said slots to said substrate array to provide accurate orientation upon each rotation.

7. A biological screening assembly as in any one of claims 1-6 wherein:

- a) at least some of said addressable areas comprise porous polyolefin discs removably received in

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5 holes in said plate; and

b) said substrate material on said discs is a hydrophilic polar multi-functionalized polymer film.

8. A biological screening system comprising in operative combination:

5 a) an inert support plate having defined thereon an array of discrete, individually addressable areas for receiving a biopolymer-retaining substrate material;

b) at least one biopolymer-retaining substrate material secured to each of said addressable areas;

10 c) at least some of said addressable areas comprise porous polyolefin-discs removably received in holes in said plate, and said substrate material on said discs is a hydrophilic polar multi-functionalized polymer film;

15 d) a border block overlying said support plate;

e) a vacuum base underlying said plate; and

20 f) means to seal said plate between said border block and vacuum plate to permit withdrawal of solution applied on said plate through said porous disc and said plate holes.

9. A method of preparing chemical polymer sequences on a continuous support substrate comprising the steps of:

5 a) superimposing on a substrate a first block having a first top and a first bottom and a plurality of first slots disposed to extend vertically between said first top and bottom;

10 b) adding a first plurality of solution of protected monomers to each of the first slots, wherein the solution in each slot comprises a different known protected monomer;

c) reacting the protected monomer solutions with the substrate to attach the protected monomer to the substrate in at least selected areas within the slot and form reacted substrate areas;

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15                   d) deprotecting at least some of the reacted substrate areas;

                  e) superimposing on the reacted substrate areas a second block having a second top and a second bottom and a plurality of second slots disposed to extend  
20                   vertically between said second top and bottom, said second block being oriented with its plurality of second slots forming an orthogonal set with said plurality of first slots;

                  f) adding a second plurality of solutions of  
25                   protected monomers to each of the second slots, wherein the solution in each slot comprises a different known protected monomer; and

                  g) reacting the second protected monomer solutions with the reacted substrate areas to attach the  
30                   second protected monomer to the reacted substrate areas to form an array of polymer sequences having known monomers in known positions in said sequences at known address locations in said array.

10. The method of claim 9 wherein:

                  a) said plurality of first slots is a plurality of linear parallel slots;

5                   b) said plurality of second slots is a plurality of linear parallel slots; and

                  c) step (e) is performed by rotating said first block 90°.

11. The method of claims 9 or 10 wherein:

                  a) other moieties may be interposed and reacted with the deprotected substrate of step (d) before reacting the second plurality of solutions of steps (e), (f) and  
5                   (g)';

                  b) the monomers are selected from the group consisting essentially of protected L-, D- and non-natural amino acids, protected DNA monomers, protected RNA monomers, protected monosaccharide units, and mixtures thereof;  
10

                  c) said first and said second protected known

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monomers are attached in said polymer sequence in any predetermined order selected from sequential to each other to separated by other moieties.

12. The method of any of claims 9-11 wherein:

a) the positions in said polymer sequence other than occupied by said known monomers are selected from the group consisting essentially of random equimolar monomers and polymers; and

b) the monomers are selected from the group consisting essentially of protected L-, D- and non-natural amino acids, protected DNA monomers, protected RNA monomers, protected monosaccharide units, and mixtures thereof.

13. The method of any of claims 9-12 wherein:

a) the positions in said polymer sequence other than occupied by said known amino acids are selected from the group consisting essentially of random equimolar mixed amino acids, dipeptides, tripeptides and polypeptides.

14. The method of any of claims 9-13 which includes the added steps of:

a) screening said array of polymer sequences having two known monomers in any known position against a preselected target to locate by address in said array on said substrate at least one polymer sequence having a desired property;

b) determining the known monomer sequence by reference to the address in said array on said substrate;

c) repeating the steps of reacting protected known monomers at determined positions in said polymer sequence different than the positions of said first and second known monomers to form a second array;

d) repeating said screening against said preselected target;

e) repeating said determination of the known monomers sequence; and



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20 f) repeating steps c, d and e at least one additional time to fully characterize the polymer sequence active with respect to said target.

15. The method of any of claims 9-14 wherein:

a) said monomers are L-, D- and non-natural amino acids; and

5 b) said polymer sequence is a hexapeptide forming an ASPCL.

16. A method of diagnosis for biologically active target molecules comprising the steps of:

5 a) providing an ASBCL plate having an addressable array of known target active sequences thereon;

b) exposing said ASBCL plate to at least one solution expected to contain at least one target; and

10 c) identifying any target in said solution by binding at an address on said array that is site specific for said target.

17. A method of diagnosis as in claim 16 wherein:

a) said ASBCL plate array includes at least some peptide sequences thereon.

18. A method of diagnosis as in claims 16 or 17 wherein:

a) said ASBCL is an ASPCL.

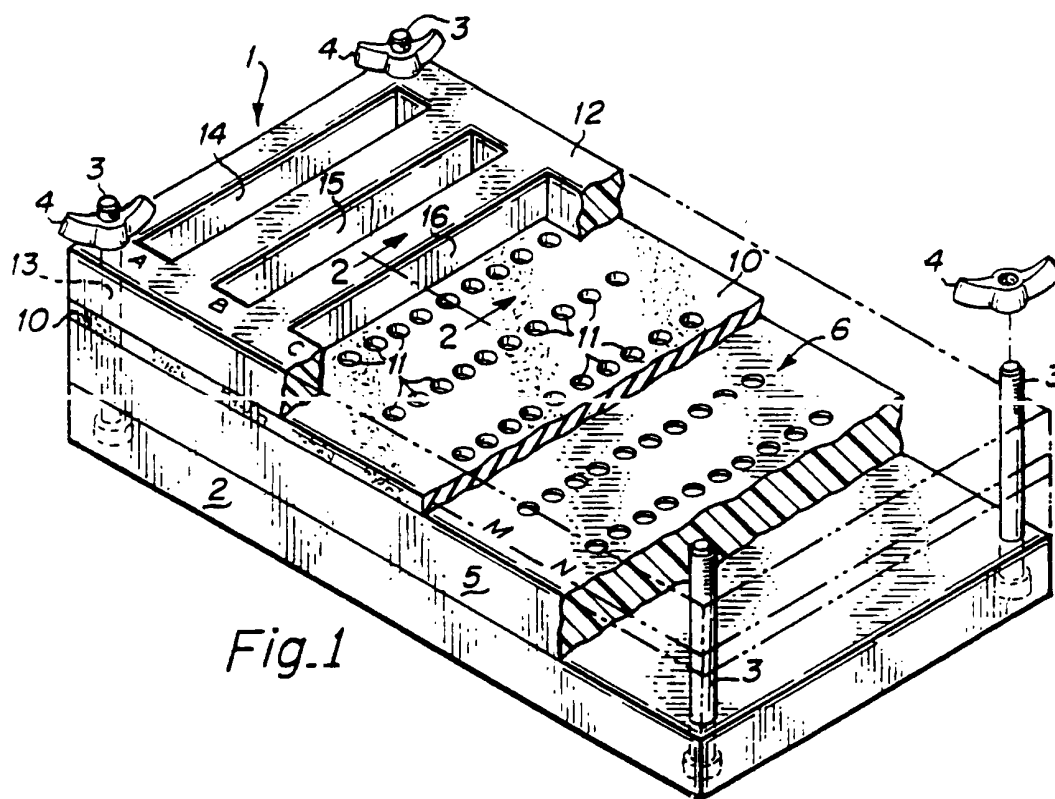


Fig. 1

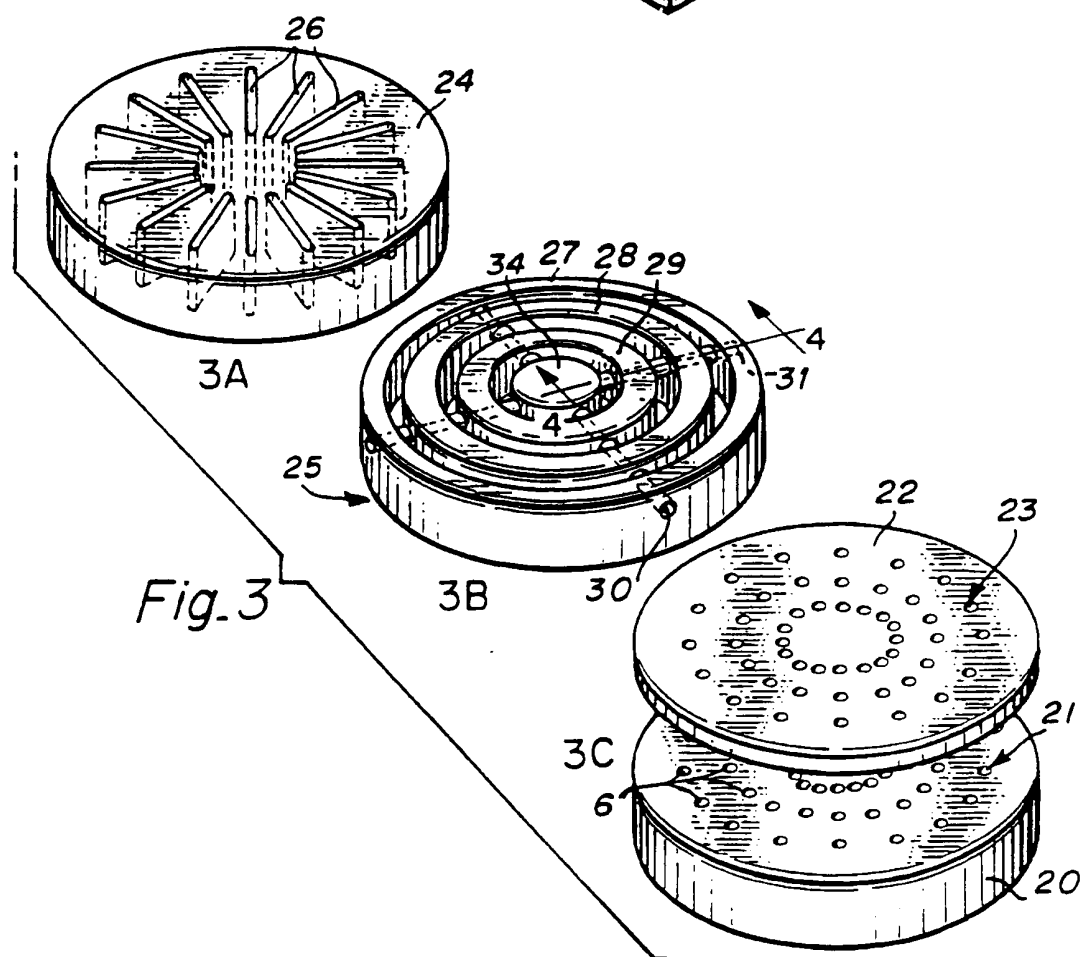


Fig. 3

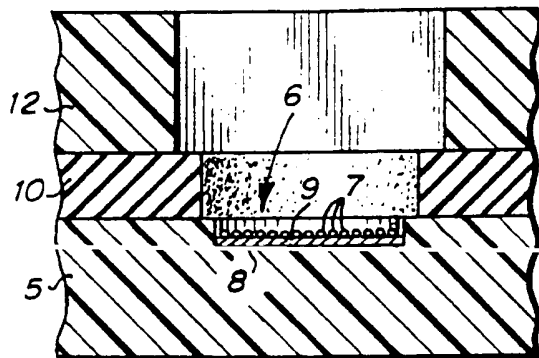


Fig. 2a

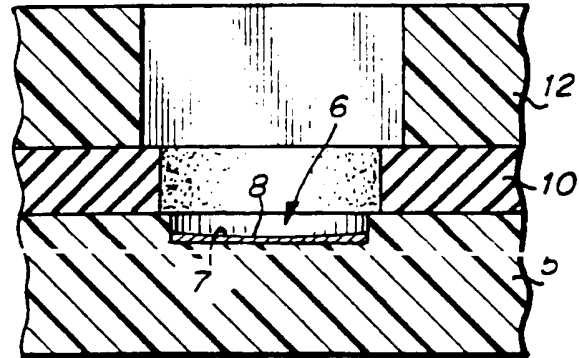


Fig. 2b

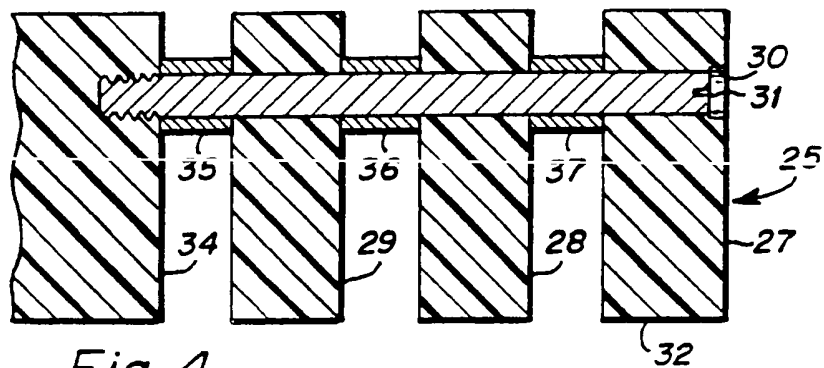


Fig. 4

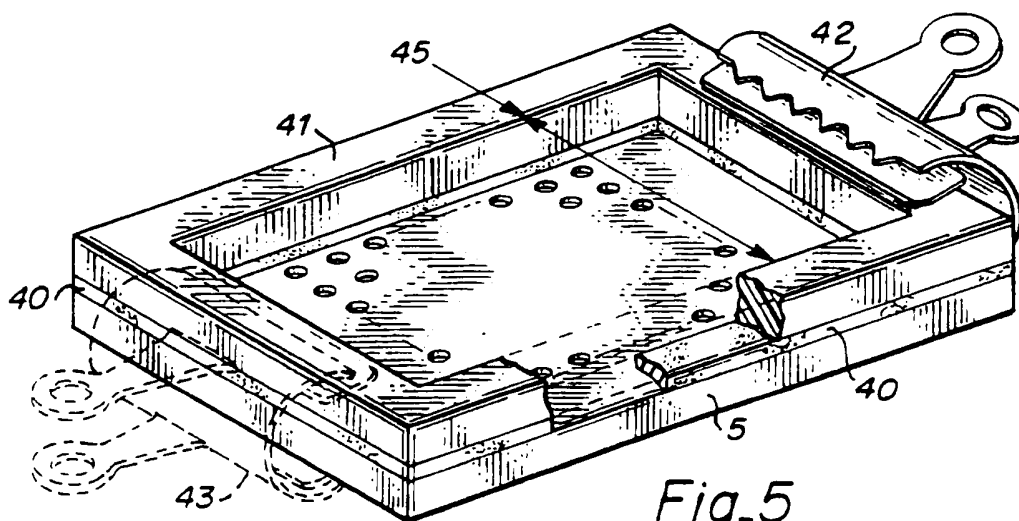


Fig. 5

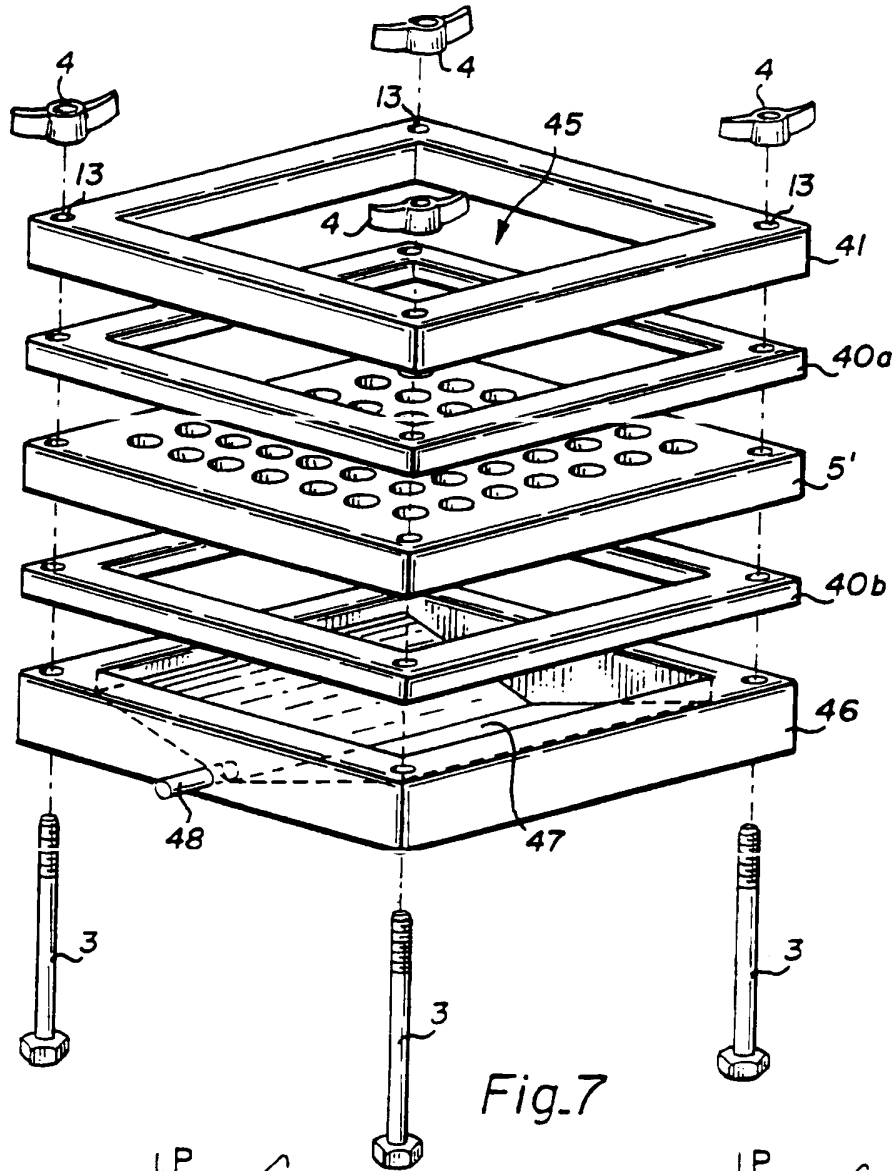


Fig. 7

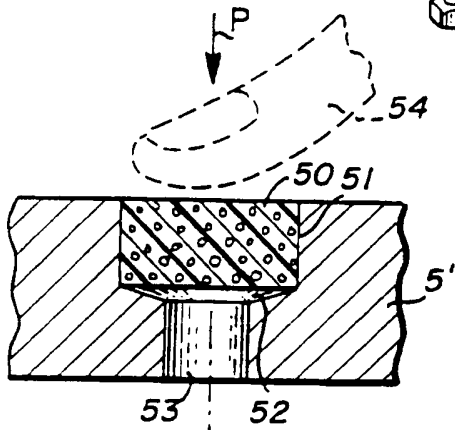


Fig. 8A

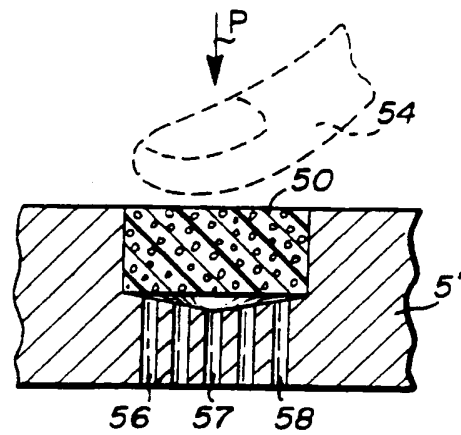
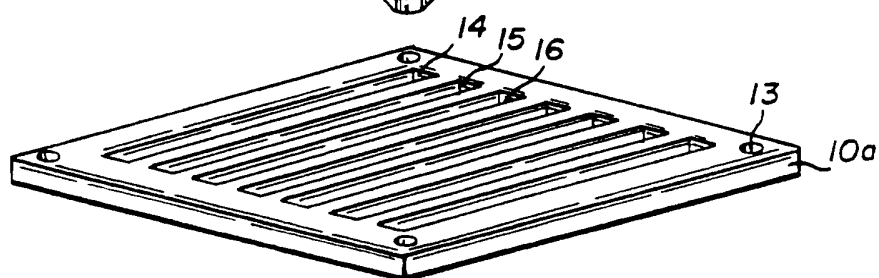
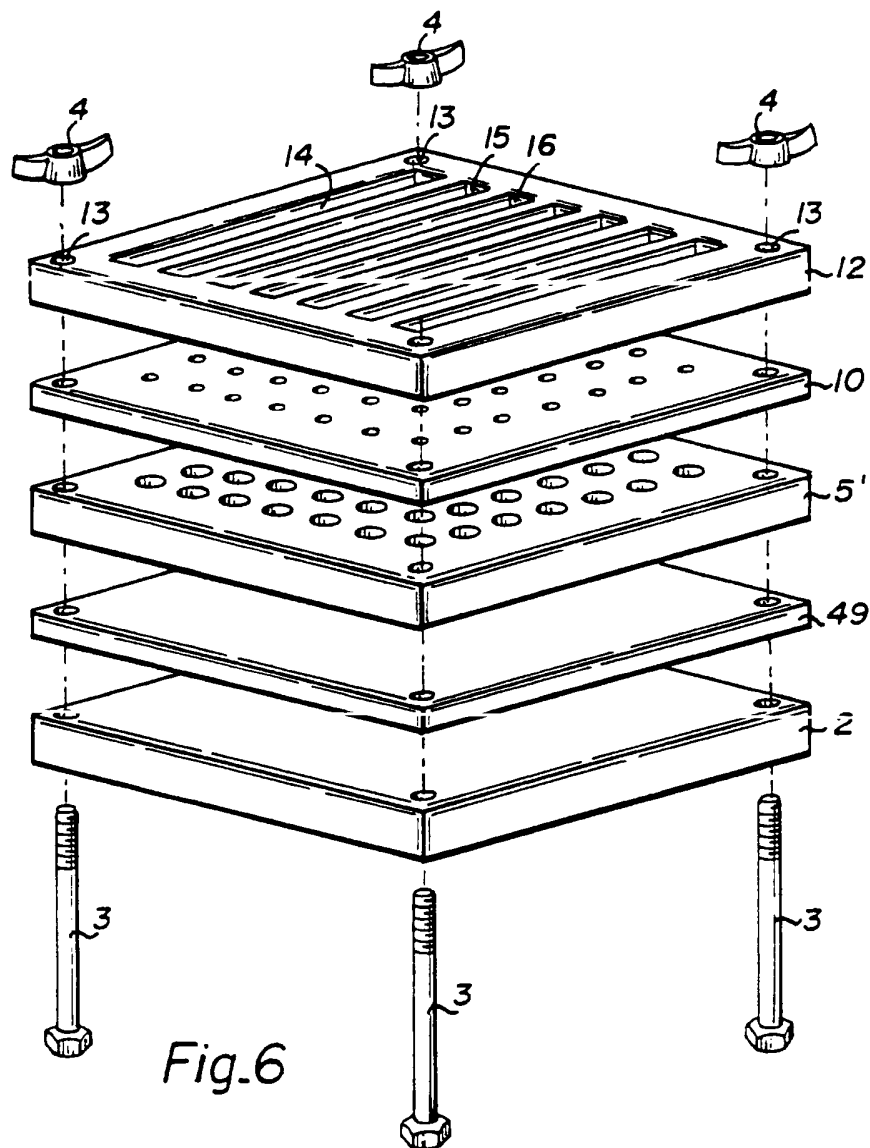


Fig. 8B



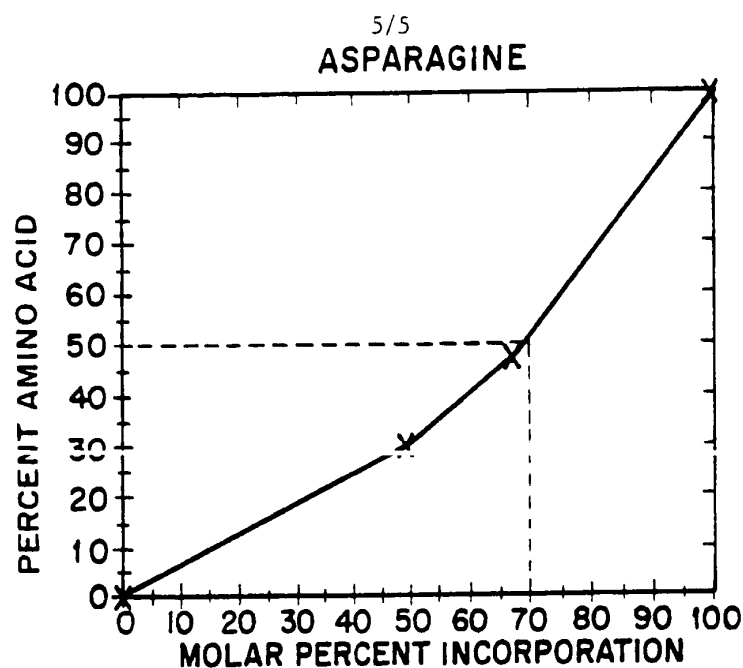


Fig.10

## ARRAY TEST 355 STREPTAVIDIN

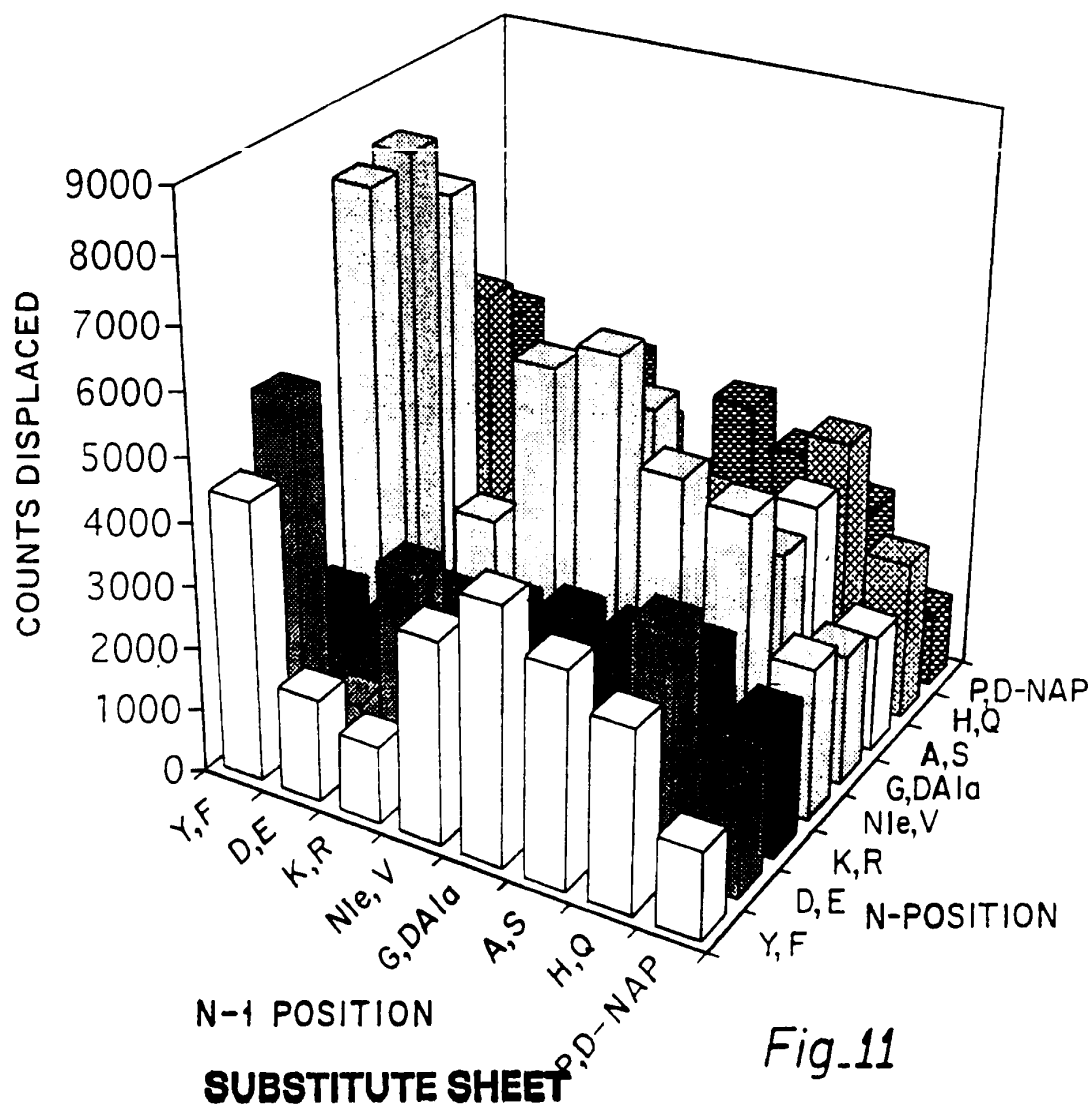


Fig.11

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US93/08267

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) : Please See Extra Sheet.

US CL : Please See Extra Sheet.

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,728,502 (Hamill) 01 March 1988, abstract, Fig. 4, col. 1, lines 49-66, col. 3, lines 13-26 and 58-62.	1-5, 8-11
<del>X</del> Y	US, A, 5,100,626 (Levin) 31 March 1992, abstract, Figs. 2-3, col. 3, lines 37-50, col. 4, lines 20-25 and 46-55, col. 5, line 18 - col. 6, line 11, col. 7, lines 25-40, col. 8, lines 35-42, col. 9, lines 8-20	<del>16-18</del> 1, 4, 6, 8-9, 11, 14-15
<del>X</del> Y	WO, A, 90/02605 (Meldal et al) 22 March 1990, abstract, page 1, lines 3-9, page 3, lines 13-16, page 6, line 24 - page 7, line 27, page 12, line 29 - page 15, line 29, Figs. 3, 6-8 and 16.	<del>1</del> 2-3, 9-13

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

* Special categories of cited documents:	*T	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be part of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z*	document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means		
*P* document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
01 DECEMBER 1993	16 DEC 1993
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer CAROL A. SPIEGEL <i>[Signature]</i>
Facsimile No. NOT APPLICABLE	Telephone No. (703) 308-0196

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	<u>Genomics</u> , volume 13, issued August 1992, E. Southern et al, "Analyzing and Comparing Nucleic Acid Sequences by Hybridization to Arrays of Oligonucleotides: Evaluation Using Experimental Models", pages 1008-1017, especially abstract, pages 1008-1011.	<u>16-18</u> 1-2, 4-5, 8-9, 11-15
X Y	US, A, 5,143,854 (Pirrung et al) 01 September 1992, abstract, Figs. 10A-10M, col. 3, line 9 - col. 4, line 27, col. 7, lines 49-62, col. 8, lines 1-7, col. 11, lines 31-38 and 51-68, col. 12, lines 43-45, col. 15, lines 9-22, col. 16, lines 18-21, 28-32 and 46-52, col. 17, line 66 - col. 18, line 3, col. 18, lines 40-68, col. 19, lines 34-37, col. 20, lines 10-32, col. 23, lines 19-67, col. 24, lines 12-14.	<u>1, 16-18</u> 2-15
Y,P	US, A, 5,188,733 (Wang et al) 23 February 1993, Figs. 1 and 3-6, col. 2, line 38 - col. 3, line 3, col. 3, lines 25-33 and 43-61, col. 4, lines 17-19, 49-51 and 56-57, claims 1-8	1-4, 7, 9, 11, 14
Y	<u>Journal of the American Chemical Society</u> , vol. 111, no. 20, issued 27 September 1989, R. Berg et al, "Long-Chain Polystyrene-Grafted Polyethylene Film Matrix: A New Support for Solid-Phase Peptide Synthesis", pages 8024-8026, especially pages 8024-8025.	1-4
Y	<u>Tetrahedron Letters</u> , vol. 33, no. 21, issued 19 May 1992, M. Meldal et al, "PEGA: A Flow Stable Polyethylene Glycol Dimethyl Acrylamide Copolymer for Solid Phase Synthesis", pages 3077-3080, especially pages 3077-3078.	3
Y,P	<u>Tetrahedron Letters</u> , vol. 34, no. 10, issued 05 March 1993, S. Kates, "A Novel, Convenient, Three-Dimensional Orthogonal Strategy for Solid-Phase Synthesis of Cyclic Peptides", pages 1549-1552, especially page 1549.	9
A	US, A, 5,053,454 (Judd) 01 October 1991, see entire document.	1-18
A,P	US, A, 5,147,608 (Hudson et al) 15 September 1992, see entire document.	1-9
A,P	US, A, 5,175,209 (Beattie et al) 29 December 1992, see entire document.	1-18
A,P	US, A, 5,196,566 (Barany et al) 23 March 1993, see entire document.	1-18



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US93/08267

## C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,P	US, A, 5,258,454 (Berg et al) 02 November 1993, see entire document	1-8

## A. CLASSIFICATION OF SUBJECT MATTER:

IPC (5):

B01D 25/12, 63/00; B01J 19/00; B01L 9/00, 11/00; C08F 283/00, 285/00; C07H 21/00; C07K 1/06, 5/00, 7/00, 15/00, 17/00; C08L 89/00; C12Q 1/00; C12P 19/04, 19/38, 21/06; G01N 21/00, 33/00, 33/543, 33/544, 33/545, 33/546, 33/552

## A. CLASSIFICATION OF SUBJECT MATTER:

US CL :

210/321.84, 321.75, 323.1, 450, 638; 422/ 56, 57, 58, 101, 102, 103, 104, 130, 131, 134, 136, 191, 209; 427/2, 491; 435/7.1, 7.92, 7.94, 69.1, 188, 287, 293, 301, 312; 436/89, 94, 518, 527, 528, 529, 531, 532; 525/54.1, 54.11; 530/333, 334, 335, 336, 337

## B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

210/321.84, 321.75, 323.1, 450, 638; 422/ 56, 57, 58, 101, 102, 103, 104, 130, 131, 134, 136, 191, 209; 427/2, 491; 435/7.1, 7.92, 7.94, 69.1, 188, 287, 293, 301, 312, 961, 973; 436/89, 94, 518, 527, 528, 529, 531, 532, 807; 525/54.1, 54.11; 530/333, 334, 335, 336, 337 935, 79, 80, 81, 82, 87, 88

## B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

## APS, DIALOG

search terms: solid phase synthesis or preparation, peptide, polypeptide, oligonucleotide, polysaccharide, amino or amine function? or derivati?, spacer, linker, handle, channel or slot block, gasket, seal, vacuum, polyolefin, polyethylene, dextran, polyethylene glycol, chitin, chitosan, polydimethylacrylamide, silica, polystyrene, crosslink?, kieselguhr

## BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

- I. Claims 1-3 and 7, drawn to an apparatus comprising a solid phase polymeric support having a substrate matrix of individually defined amino-functionalized areas for chemically anchoring biopolymers thereto, wherein the substrate is preferably a polymer film having low molar percentage of crosslinking covalently grafted to the support, classified in class 435, subclass 174..
- II. Claims 4-7, drawn to a channel block apparatus comprising a common well access to an inert support having a substrate matrix of individually defined areas for attaching biopolymers thereto, wherein the substrate preferably comprises a hydrophilic polar multi-functionalized polymer film attached to a support preferably comprising porous polyolefin discs, classified in class 422, subclass 131.
- III. Claim 8, drawn to an apparatus for synthesizing biopolymers comprising a support having individual holes containing a hydrophilic polar multi-functionalized polymer film attached porous polyolefin discs, sandwiched between an overlying border block and an underlying vacuum base, and a sealing means capable of providing fluid flow through the porous discs, classified in class 422, subclass 104.
- IV. Claims 9-13, drawn to methods for synthesizing polymers in an apparatus comprising a plurality of rotatable slot blocks and using random equimolar monomers and polymers comprising protected amino acids, protected nucleic acids and protected monosaccharides, classified in class 530, subclass 333.
- V. Claim 14, drawn to a method of synthesizing and individually screening an array of discrete polymer sequences on a substrate for reactivity against a preselected target, classified in class 436, subclass 518.
- VI. Claims 15-18, drawn to methods for screening a synthetic peptide combinatorial library in order to determine which polypeptides specifically bind to a known target receptor, classified in class 435, subclass 7.1.